AUGUST 1954

Journal

VOL. 46 • NO. 8

AMERICAN WATER WORKS ASSOCIATION

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but it's no help in a fire hydrant

Friction causes loss of water pressure and reduces the effectiveness of fire-fighting equipment. That's why R. D. Wood Hydrants are designed to cut friction way down—and why so many communities rely on them for fire protection.

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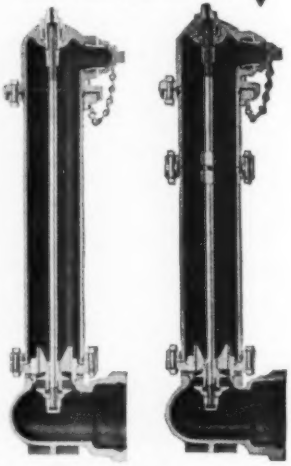

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Public Ledger Building, Philadelphia, Pa.

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Journal

AMERICAN WATER WORKS ASSOCIATION

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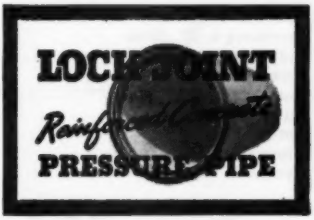

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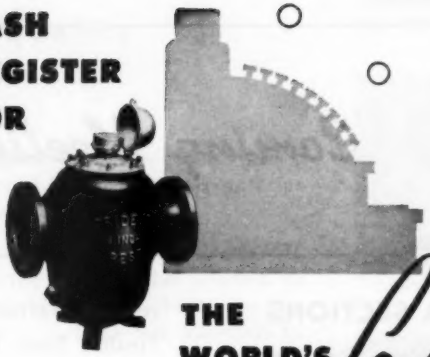

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AWWA ANNUAL CONFERENCE

Chicago, Ill. June 12-17, 1955

Coming Meetings

AWWA SECTIONS

Sept. 9–10—New York Section at Montauk Manor, Montauk, L.I. Secretary, Kimball Blanchard, Rm. 1922, 50 W. 50th St., New York 20, N.Y.

Sept. 15–17—Michigan Section at Occidental Hotel, Muskegon. Secretary, T. L. Vander Velde, Chief, Secretary of Water Supply, State Dept. of Health, Lansing 4, Mich.

Sept. 20–22—Kentucky-Tennessee Section at Andrew Jackson Hotel, Nashville, Tenn. Secretary, J. Wiley Finney Jr., Asst. Director, Div. of San. Eng., State Dept. of Public Health, 420—6th Ave., N., Nashville 3, Tenn.

Sept. 22–24—Ohio Section at Biltmore Hotel, Dayton. Secretary, M. E. Druley, Manager, Dayton Power & Light Co., Wilmington, Ohio.

Sept. 26–28—Missouri Section at Hotel Governor, Jefferson City. Secretary, Warren A. Kramer, Div. of Health, State Office Bldg., Jefferson City, Mo.

Sept. 28–30—Wisconsin Section at Hotel Northland, Green Bay. Secretary, Leon A. Smith, Supt. Water & Sewerage, City Hall, Madison 3, Wis.

October 4–5—Maritime Branch, Canadian Section at Hotel Brunswick, Moncton, New Brunswick. Secretary, J. D. Kline, P.O. Box 574, Halifax, N.S.

Oct. 6–8—Minnesota Section at Lowry Hotel, St. Paul. Secretary, Leonard N. Thompson, Gen. Mgr., Water Dept., St. Paul 2, Minn.

Oct. 13–15—Iowa Section at Hotel Roosevelt, Cedar Rapids. Secretary, H. V. Pedersen, Supt. of Water Works, Municipal Bldg., Marshalltown, Iowa.

(Continued on page 8)

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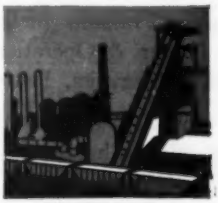
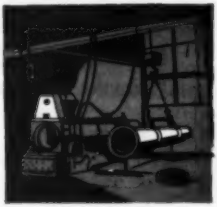
Ore and Coal Mines

Coke Ovens



Blast Furnaces



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U. S. PIPE & FOUNDRY COMPANY

GENERAL OFFICES: BIRMINGHAM 2, ALABAMA

A wholly integrated producer . . . from mines and blast furnaces to finished pipe.

Coming Meetings

(Continued from page 6)

Oct. 17–20—Southwest Section at Cortez Hotel, El Paso, Tex. Secretary, Leslie A. Jackson, Mgr.-Engr., Municipal Water Works, Robinson Memorial Auditorium, Little Rock, Ark.

Oct. 24–27—Alabama-Mississippi Section at Tutwiler Hotel, Birmingham, Ala. Secretary, Charles W. White, Asst. San. Engr., State Dept. of Public Health, 537 Dexter Ave., Montgomery 4, Ala.

Oct. 26–29—California Section at Wilton Hotel, Long Beach. Secretary, Henry Franklin Jerauld, Asst. Supt. of Constr. & Operation, Water Dept., 1040 Manzanita, Pasadena 3, Calif.

Oct. 27–29—Chesapeake Section at Belvedere Sheraton Hotel, Baltimore, Md. Secretary, Carl J. Lauter, 6955—33rd St., Washington 15, D.C.

Nov. 3–5—Virginia Section at Jefferson Hotel, Richmond. Secretary, J. P. Kavanagh, 213 Carlton Terrace Bldg., Roanoke 11, Va.

Nov. 4–6—New Jersey Section at Madison Hotel, Atlantic City. Secretary, C. B. Tygert, Wallace & Tiernan, Inc., Box 178, Newark 1, N.J.

Nov. 7–10—Florida Section at Soreno Hotel, St. Petersburg. Secretary, Harvey T. Skaggs, Secy. & Gen. Mgr., Amica-Burnett Chemical Co., Box 2328, Jacksonville, Fla.

Nov. 8–9—West Virginia Section at Prichard Hotel, Huntington. Secretary, H. K. Gidley, Director, Div. of San. Eng., State Dept. of Health, Charleston 5, W.Va.

Nov. 8–10—North Carolina Section at George Vanderbilt Hotel, Asheville. Secretary, E. C. Hubbard, Exec. Secy., State Stream Sanitation Com., Box 2091, Raleigh, N.C.

Nov. 9–10—Rocky Mountain Section at Broadmoor Hotel, Colorado Springs, Colo. Secretary, George J. Turre, San. Engr., Board of Water Comrs., Box 600, Denver, Colo.

Dec. 2–4—Cuban Section at Sociedad Cubana de Ingenieros, Havana. Secretary, Laurence H. Daniel, Pres., Laurence H. Daniel, Inc., Baratillo 9, Havana, Cuba.

OTHER ORGANIZATIONS

Aug. 2–12—Pan American Federation of Engineering Associations (UPADI) at Sao Paulo, Brazil

Sep. 28–30—South Dakota Water & Sewage Works Conference, in Mitchell, S.D.

Oct. 3–6—New England Water Works Assn., Poland Springs, Me.

Oct. 11–14—Federation of Sewage & Industrial Wastes Assns., in Cincinnati.

Oct. 11–15—American Public Health Assn., in Buffalo

Oct. 17–20—American Society of Civil Engineers, in New York City

Oct. 19–21—Public Utilities Sessions, National Safety Congress, Chicago

Oct. 19–22—Pennsylvania Water Works Assn., in Atlantic City, N.J.

Nov. 17–19—Water Works Management Short Course, at Univ. of Illinois, Allerton Park, Ill.

Nov. 28–Dec. 3—American Society of Mechanical Engineers, in New York

Save time and money on water line installation

In this Georgia installation, faster line assembly permitted following the digger closely.

On this Utah job, snow, ice and frozen ground caused no installation slow-down.

Transite® Pressure Pipe with the new Ring-Tite® Coupling

Goes together fast! Locks tight automatically!

In state after state, community after community, Transite Pressure Pipe and the new Ring-Tite Coupling have made possible important cost-savings in installation time.

The Ring-Tite Coupling is effecting installation savings everywhere because of its special features. To begin with, pipes are aligned quickly, easily. Coupling design not only provides automatic aligning but also automatic adjustment for expansion. Rubber rings are simply popped into grooves for assembly; lubricated pipe ends then slide in under rings smoothly, easily, and surely. Pipe ends are automatically separated within the coupling. This separation gives the line flexibility to withstand shock and vibration, relieves line stresses, permits conformance to curves.

Like Transite Pressure Pipe, the Ring-Tite Coupling sleeve is made of asbestos and cement . . . it is strong and durable, cannot rust, and is highly resistant to corrosion. Installations can be completed under adverse weather, temperature or terrain conditions. No complicated equipment is required.

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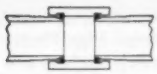
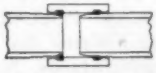


A. Rubber rings popped into grooves before assembly.



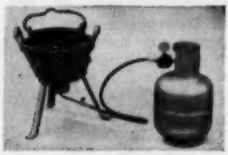
B. Lubricated pipe slides in under rubber rings.

C. Both pipes in assembled position. Rings compressed and locked in place.

JM PRODUCTS **Johns-Manville TRANSITE PRESSURE PIPE**
AN ASBESTOS-CEMENT PRODUCT

Pipe Line Equipment
WATER • GAS • SEWER

Bottled Gas Lead Melting Furnace

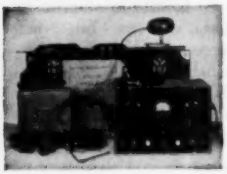


Asbestos Joint Runners

Best quality asbestos rope, brass caps attached to each end. Equipped with clamps.

M-D Cut-In Connections for Sewers

A light cast iron fitting with bell end for connecting house service with main sewer pipe without necessity for placing a Y-branch or T-branch in the sewer line.



Leak Detector

A truly fine instrument designed to solve even the most difficult leak detecting problem.

Calking Tool Outfit

For water mains up to 12". Strong leather bag. Keeps the right tool for every job within easy reach.

Test Plugs for Bell or Spigot End Cast Iron Pipe.

On this page are shown only a few of the hundreds of items to be found in the POLLARD Catalog. Write for a copy of Catalog No. 25K.

Portable Lead Melting Furnace

A handy outfit for quick action, equipped with gasoline burner.

Pipe Cutter

Inexpensive way of cutting pipe. Every wheel in contact with the pipe is a cutting disc, so cutter need be moved only a short distance to cut entirely around the pipe.

Tapax

The original manhole cushion. Takes the bang out of manhole covers.

M-Scope Pipe Finder

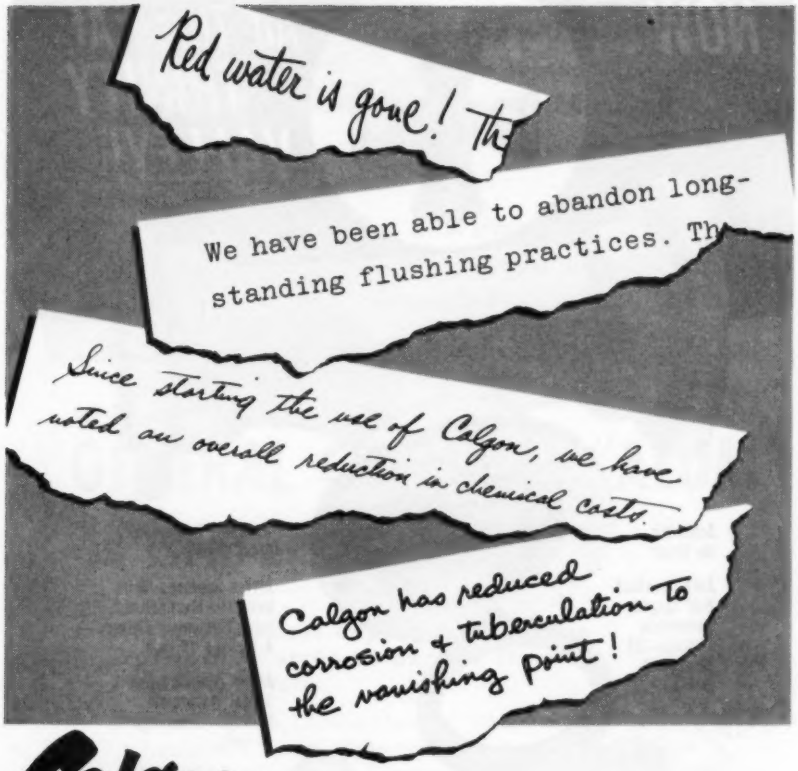
It's easy to locate a buried pipe line with this handy pipe finder.

JOSEPH G. POLLARD CO., INC.

Western Office
1064 Peoples Gas Bldg.
Chicago, Ill.

MAIN OFFICE AND FACTORY
New Hyde Park, N. Y.

Southern Office
333 Candler Bldg.
Atlanta, GA.


Red water is gone! Th
We have been able to abandon long-standing flushing practices. Th
Since starting the use of Calgon, we have noted an overall reduction in chemical costs.
Calgon has reduced corrosion & tuberculation to the vanishing point!

Calgon* **cures water problems...saves money**

These are a few of the comments made by water departments from coast to coast after initiating the use of Calgon.

The remarkable properties of Calgon make its use a simple and economical method of controlling corrosion,† reducing tuberculation and eliminating discolored water in municipal and industrial systems.

The accumulated experience of years of service to water departments all over the country is at your disposal. Write or phone for help with your particular problem.

CALGON Inc.

HAGAN HALL BURDMIN CALGON

A SUBSIDIARY OF HAGAN CORPORATION HAGAN BUILDING PITTSBURGH 30, PA.

*Calgon is the Registered Trade Mark of Calgon, Inc. for its glassy phosphate (sodium hexametaphosphate) products.
†Fully licensed for use under U.S. Patent 2,337,856.

NOW . . All Three At TRINITY VALLEY!

Available On Order

AWA Standard Bell Spigot Watermain Fittings—24 through 36 inch.

Available Immediately From Stock

AWWA Approved Short Body and Mechanical Joint Watermain Fittings—4 through 12 inch.

AWWA Standard Bell Spigot Watermain Fittings—2 through 24 inch.

TRINITY VALLEY IRON AND STEEL CO.

Phone PErshing 3141 Fort Worth, Texas P. O. Box 664

for water:
To remove turbidity, color and other impurities

for sewage:
For clarification . . . to floc out suspended colloids and solids—
For sludge . . . to speed drying

GENERAL CHEMICAL "ALUM" is preferred

Here's why water experts and sewage experts alike agree on General Chemical Aluminum Sulfate.

For over 50 years, General Chemical "Alum" has had a reputation for meeting the most rigid chemical and physical specifications of the water and sewage industry. In scores of cities throughout America, public works officials depend on its uniformity and quality.

And, they also depend upon General's coast-to-coast producing and distributing facilities to meet their day-to-day and emergency needs. General has an "alum" supply point near you, too. So, for your operations, specify the *preferred* aluminum sulfate—General Chemical "Alum."

GC Allied Chemical

GENERAL CHEMICAL DIVISION
ALLIED CHEMICAL & DYE CORPORATION
40 Rector Street, New York 6, N. Y.

Offices: Albany • Atlanta • Baltimore • Birmingham • Boston Bridgeport • Buffalo • Charlotte • Chicago • Cleveland • Denver Detroit • Greenville (Miss.) • Houston • Jacksonville • Kalamazoo Los Angeles • Minneapolis • New York • Philadelphia • Pittsburgh Providence • San Francisco • Seattle • St. Louis • Yakima (Wash.)

In Wisconsin: General Chemical Company, Inc., Milwaukee

In Canada: The Nichols Chemical Company, Ltd. • Montreal • Toronto • Vancouver

With 100 years

Ewing Galloway

This is New York, as seen from East River, showing Empire State, Chrysler and United Nations buildings.

Bettmann Archive

Old print showing cast iron water mains being installed in New York about 100 years ago.

MODERNIZED **cast iron**

# of EXPERIENCE... they must be right!

NEW YORK installed cast iron water mains 100 years ago... and installs them today!

One hundred years ago, New York was a city of about 750,000 population, served by 237 miles of water mains. Today's eight million population requires 5500 miles of mains, of which 98% are cast iron. Some of these mains are still functioning after a century and more of service. From 90 M.G.D. a century ago, capacity has grown to 1500 M.G.D.

In good condition after 100 years of service, this cast iron distribution main is one of several still functioning in New York City.

A customer who buys your product year after year—generation after generation—is a "jewel beyond price". Be you merchant or manufacturer, you might count such customers on the fingers of your two hands. Yet, the cast iron pressure pipe industry can count more than 60 of them—utilities that have been buying cast iron pipe for water or gas mains (or both) for 100 years.

Cast iron pipe has been a rugged, long-lived product from the earliest days. Today's *modernized* cast iron pipe, centrifugally cast, is even stronger, tougher, and more uniform in quality. And, where needed and specified, it is centrifugally lined with cement mortar to assure sustained carrying capacity throughout the long life of the pipe.

Cast Iron Pipe Research Association, Thos. F. Wolfe, Managing Director, 122 So. Michigan Ave., Chicago 3.

CAST IRON

The Q-Check stencilled on pipe is the Registered Service Mark of the Cast Iron Pipe Research Association.

pipe FOR MODERN WATER WORKS OPERATION

A Service

that knows no boundaries

From Alaska to Zamboanga and points North, East, South and West, wherever man has a need for water—there you will find Layne.

It's a typical American success story—this history that spans nearly three quarters of a century and started with a one man muscle power drilling rig—and an idea.

Today Layne is the name of a product—but it's more than that—much more. The name Layne is also the name of a service, international in scope, that includes every phase of ground water development from preliminary exploration to maintenance of installed equipment.

For information on any phase of ground water development, modernization, maintenance or equipment consult your nearest Layne Associate Company—or write

LAYNE & BOWLER, INC., *Memphis 8, Tennessee*

Water Wells
Vertical Turbine Pumps
Water Treatment

Layne Associate Companies Throughout the World

In making reinforced concrete pipe for water supply lines~

permanent plants and jobsite plants put us close to any Western project

If your pipeline project is anywhere in the Western States — there is an American plant to serve you . . . equipped to supply quality pipe products . . . organized for efficient service.

Most job requirements can be met by existing plants strategically located throughout the West, but where distance and transportation factors exist and where the quantity of pipe involved is sufficient, it is frequently advantageous to set up pipe-making plants near the jobsite.

In the past few years American Pipe and Construction Co. has established many jobsite plants throughout the West. Substantial savings have been realized, for customers and manufacturer alike, by erecting these plants close to the project.

Wherever your next project is to be, we would like to help you plan it. An inquiry directed to any of our regional offices will receive prompt attention.

NOW AVAILABLE

New Bulletin No. 12

"Representative List of Installations"

. . . indicative of the wide scope of American activities. Address requests to P. O. Box 3428, Terminal Annex, Los Angeles 54, California.

American PIPE AND CONSTRUCTION CO.

Main Offices and Plant: 4635 Firestone Blvd., South Gate, California
District Sales Offices and Plants: Hayward • San Diego • Portland, Ore.
Concrete pipe for main water supply lines, storm and sanitary sewers, subaqueous pipe lines

Let's assume your current piping maintenance labor rate, including burden, is $3.85. Less than 10 minutes is all you would get for 60 cents. Time to write a valve repair ticket and gather up tools—no more!

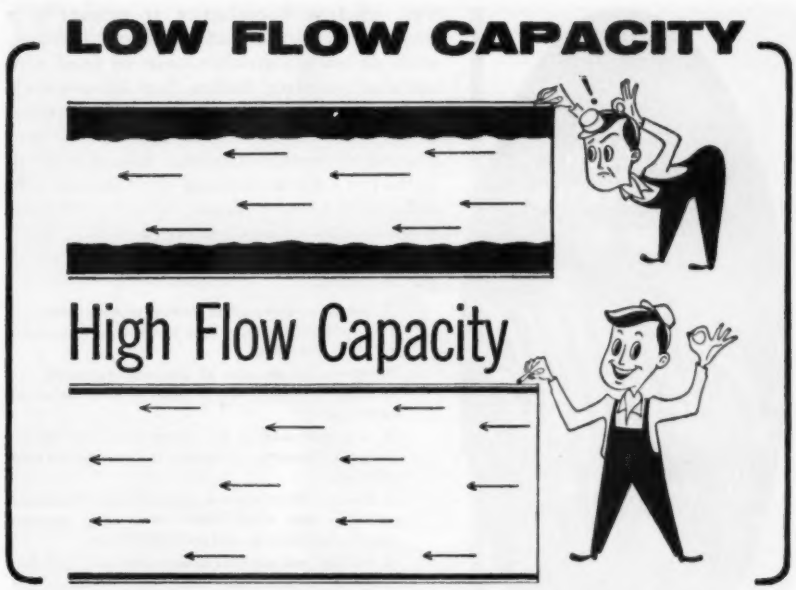
40—60—80 cents—it's a small difference in the price of valves that often makes the big difference in quality—and your ultimate cost! The thrifty buyer takes no chances with "bargain" valves and high maintenance. He knows a single valve failure can cost many times more than the dubious saving on his whole valve order.

It's safer . . . more economical . . . more sensible to stay with Crane quality. There's no better assurance of low-cost dependability on the job. That's why more Crane valves are in use than any other make.

CRANE

CRANE CO., *General Offices:* 836 S. Michigan Ave., Chicago 5, Illinois
Branches and Wholesalers Serving All Industrial Areas

VALVES • FITTINGS • PIPE • PLUMBING • HEATING



. . . Bitumastic 70-B Enamel makes the difference by preventing corrosion

● Flow capacity *stays* high when Bitumastic® 70-B Enamel protects interior surfaces of steel pipe lines. This durable enamel prevents rust, corrosion, incrustation and tuberculation... keeps pipe lines from "shrinking." With this kind of protection, there's no need to spend money on *over-sized* pipe in order to allow for future loss in flow capacity. Flow tests conducted on steel pipe lines, centrifugally lined with hot Bitumastic 70-B Enamel, have shown the value of Hazen-Williams coefficient "C"=145 to 160.

BITUMASTIC PROTECTION 100th Anniversary 1854 1954

You can save money in another way with Bitumastic 70-B Enamel. When applied to a thickness of 3/32", it protects the exterior of pipe against the corrosive action of the soil. It is wasteful to specify an excess of wall thickness to compensate for corrosion. It is more economical to specify just enough wall thickness to give the pipe adequate structural strength and to use Bitumastic 70-B Enamel to prevent corrosion.

Use strong, durable steel pipe, lined and coated with Bitumastic 70-B Enamel, and give your community worthwhile savings. Write for full information on protecting large-diameter water lines.

KOPPERS BITUMASTIC ENAMELS ®

KOPPERS COMPANY, INC.

Tar Products Division, Dept. 805-T, Pittsburgh 19, Pennsylvania

DISTRICT OFFICES: BOSTON, CHICAGO, LOS ANGELES, NEW YORK, PITTSBURGH, AND WOODWARD, ALA.

EFFICIENT FLOCCULATION IS A

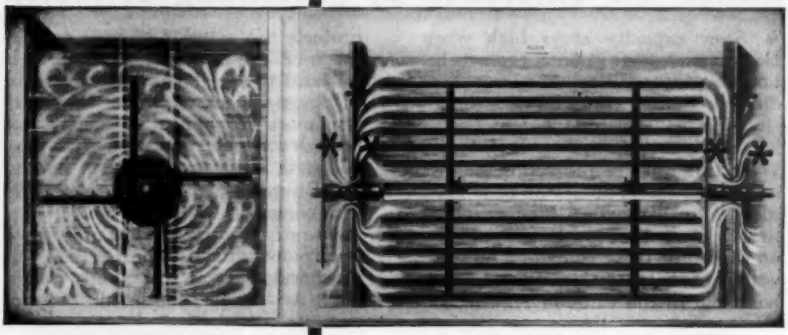
"BAFFLING"

PROBLEM

Yes, efficient flocculation is primarily a problem of correct baffling. Rex® Floctrol, with its unique combination of fixed and circular rotating baffles (*see illustration*), makes possible more thorough mixing, holds short circuiting to a minimum and assures efficient flocculation. Use of Floctrol in the pre-treatment stage often means considerably greater plant capacity without construction of additional facilities. With Rex Floctrol you get these outstanding advantages:

1. All flow directed to active mixing area . . . complete utilization of tank volume . . . practically no short circuiting.
2. Minimum amount of chemical required . . . thorough mixing assures positive reaction of all chemicals.
3. Tapered mixing by zones . . . the proved Langelier Process . . . assures large, readily settleable floc.
4. Extreme flexibility—a variety of paddle speeds, paddle areas, zone lengths and drive arrangements available to suit any conditions.
5. Paddle axis parallel to line of flow . . . all flow receives uniform treatment in each zone.

For all the facts, call your nearest Rex Field Sales Engineer or write for Bulletin 48-39. Chain Belt Company, 4609 W. Greenfield Ave., Milwaukee 1, Wis.



Cross-sectional view from head of tank showing mixing action.

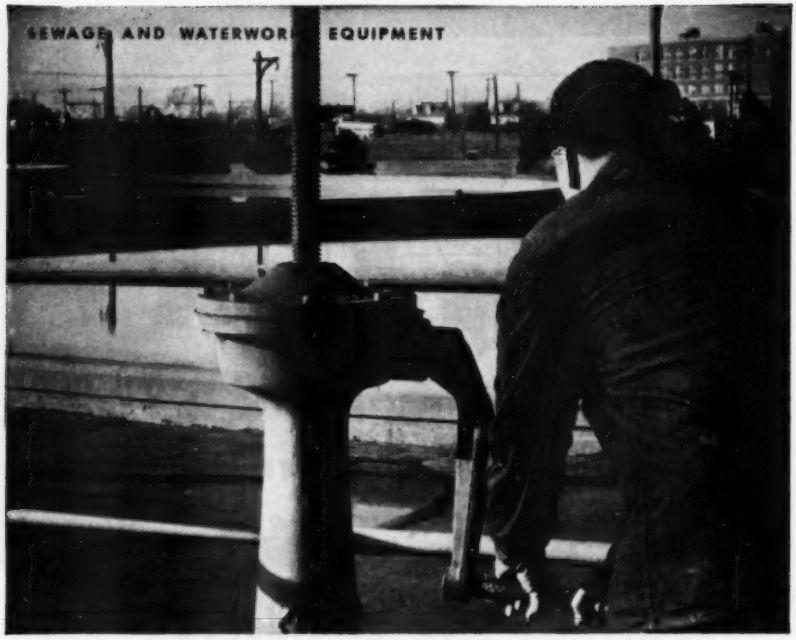
Cross-sectional side view of Floctrol showing flow.

REX **Chain Belt** COMPANY
OF MILWAUKEE

Atlanta • Baltimore • Birmingham • Boston • Buffalo • Chicago • Cincinnati • Cleveland • Dallas Denver • Detroit • El Paso • Houston • Indianapolis • Jacksonville • Kansas City • Los Angeles Louisville • Midland, Texas • Milwaukee • Minneapolis • New York • Philadelphia • Pittsburgh Portland, Ore. • West Springfield, Mass. • St. Louis • Salt Lake City • San Francisco • Seattle Tulsa • Worcester

Distributors in Principal Cities in the United States and Abroad
Export Offices: 4800 W. Mitchell St., Milwaukee; and 19 Rector St., New York City

PRINTED IN U.S.A.



EVERDUR STEMS:

TURN THEM EASILY—ONCE A DAY OR ONCE A YEAR. THEY RESIST CORROSION.

Rust and efficiency—like oil and water—don't mix. In gate and valve stems rust costs money. You avoid this by specifying stems made of Everdur*—*strong, rustproof and corrosion-resistant.*

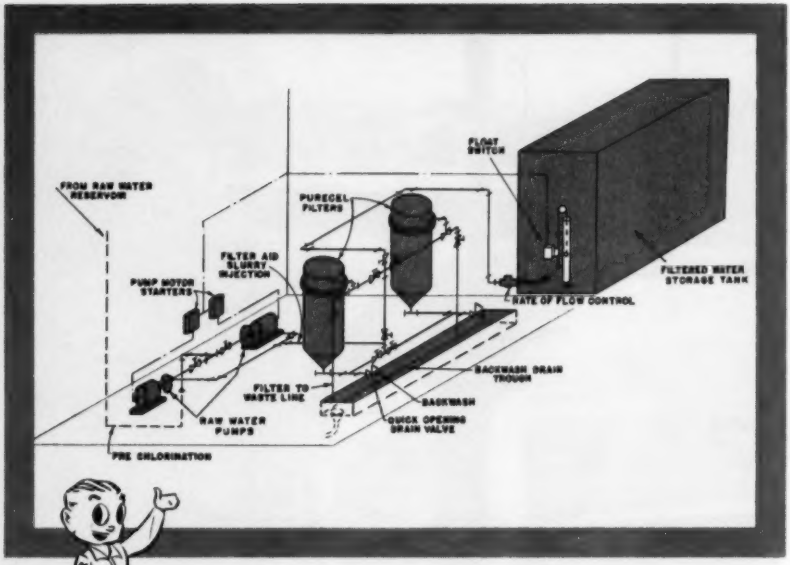
Everdur Copper-Silicon Alloys have long been fabricated into lightweight sewage and waterworks structures. Gates, screens, guides and bolts, weirs, float chambers, troughs, manhole steps and electrical conduit—all gain *extra* protection when made of Everdur.

Depending on the type or composition, you can work Everdur Alloys hot or cold, and readily form, forge, weld and machine them. They are available in plates, sheets, rods, tubes, electrical conduit and casting ingots.

Write for free booklet, "Everdur Copper-Silicon Alloys for Sewage and Waterworks Equipment." For practical advice on selecting the correct material for your equipment, consult our Technical Department. Their services are freely available. *The American Brass Company, Waterbury 20, Connecticut. In Canada: Anaconda American Brass Ltd., New Toronto, Ont.*

*Reg. U. S. Pat. Off. 53139A

EVERDUR
ANACONDA®
COPPER-SILICON ALLOYS
STRONG • WELDABLE • WORKABLE
CORROSION-RESISTANT



Have You Considered Purecel Filtration for Potable Water Supplies?

When properly engineered and applied, a Purecel Diatomaceous Earth Filtration Plant can save a large percentage of the cost of a conventional sand filter plant, and can provide important operational economies as well. Several full-scale installations have already been made with very gratifying results.

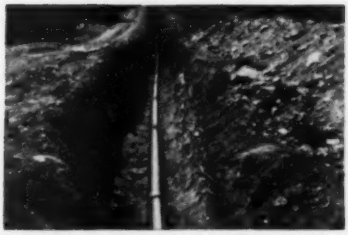
We will be glad to give you the benefit of our experience with this new type of water filtration system. Write us for data and recommendations on a pilot installation for your water supply . . . also ask for Bulletins 1800-S and 1800-1 (reprints of recent technical articles on diatomite filtration case histories). Proportioneers, Inc., 365 Harris Ave., Providence 1, R. I. Technical service representatives in principal cities of the United States, Canada, Mexico, and foreign countries.

PROPORTIONEERS

DIVISION OF B-I-F INDUSTRIES, INC.

BUILDERS IRON FOUNDRY • OMEGA MACHINE CO. • BUILDERS-PROVIDENCE, INC.

METERS
FEEDERS
CONTROLS



"Century" Pipe installation, Brookwood Estates, Stanhope, N. J.

PERMANENT STRENGTH

"CENTURY®" PIPE

as its name suggests, retains its great strength for generations. One reason is that the materials used to make it (asbestos fiber and portland cement) are themselves inherently strong and durable. Secondly, K&M maintains rigid quality control throughout the manufacturing process. To be certain of high strength and uniformity of construction, K&M tests every length, both hydrostatically and in flexure, before it leaves the plant. "Century" pipe has proved its strength by long service in many kinds of soil.

Consider the many other distinct advantages of "Century" pipe and you'll see why more and more thrifty towns are choosing it—why it's the wise choice for your community too!

Write for further information now.

QUALITIES THAT MAKE "CENTURY" PIPE ECONOMICAL, TROUBLE-FREE, LONG-LIVED

1. NON-TUBERCULATING
2. NON-CORROSIVE
3. PERMANENT STRENGTH
4. DURABLE
5. IMMUNE TO ELECTROLYSIS
6. TIGHT JOINTS
7. SMOOTH BORE
8. EASILY, QUICKLY LAID
9. LIGHT WEIGHT
10. LOW COST

"Century" pipe meets the A.W.W.A., A.S.T.M. and Federal Specifications for asbestos-cement pressure pipe.

KEASBEY & MATTISON COMPANY

AMBLER • PENNSYLVANIA

K&M best in asbestos ®

Nature made asbestos . . . Keasbey & Mattison has made it serve mankind since 1873

DELIVERS WATER CHEAPER

San Jose installs 12-mile Dresser-Coupled steel line . . . augments water supply from new reservoir.

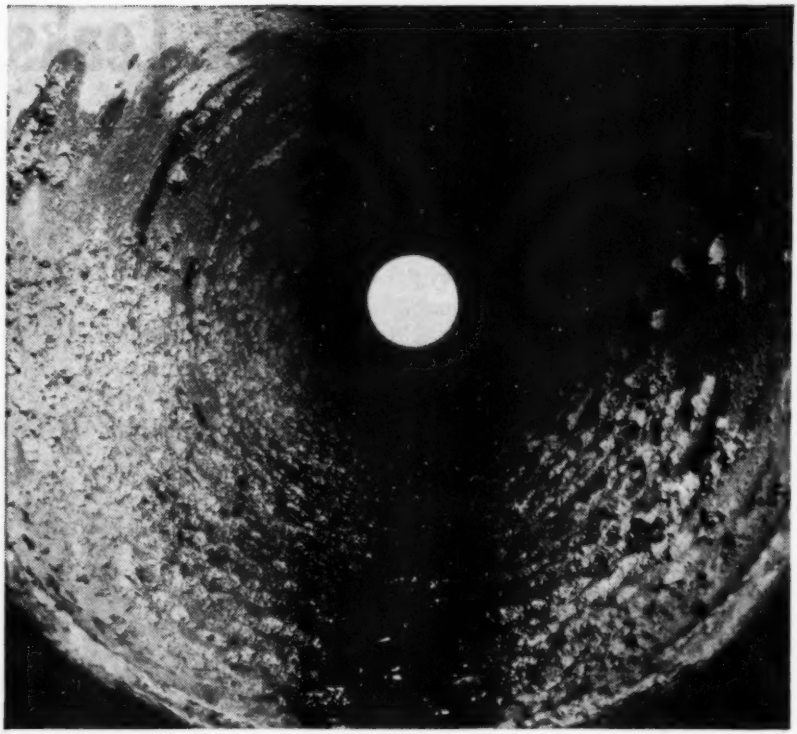
Crossing the new Water Conservation District reservoir—replacing 8,000 ft. of flume, now submerged—this Dresser-Coupled steel line carries an increased water supply to San Jose, Los Gatos and Saratoga, California. Having installed over 200 miles of steel pipe since 1946, San Jose engineers are well acquainted with the many advantages of Dresser-Coupled construction.

The beam strength of lighter weight steel pipe, plus the resilience of both pipe and couplings, assures a permanently tight line unaffected by surface shock, ground shift or washouts. Rugged coatings make the line impervious to corrosion and incrustation. Glass-smooth pipe linings sustain high flow-coefficients.

Long pipe lengths require fewer joints per mile—reduce laying costs. Small crews, with a minimum of skill, supervision and heavy equipment, make Dresser joints faster, surer—speed construction schedules. This adds up to lower cost, maintenance-free lines.

✓ ***BE SURE*** **you get the *best* line at the *best* price. Always put steel pipe and Dresser Couplings in *your* specifications.**

DRESSER® COUPLINGS Dresser Manufacturing Division, 69 Fisher Ave., Bradford, Pa. (One of the Dresser Industries).



Don't let your pipeline get "TB"

Tuberculated pipe is one of many hazards which drastically reduce pipeline efficiency. Avoid this cause of capacity losses by specifying Barrett Waterworks Enamel for your pipeline operations.

Barrett Waterworks Enamel is of the highest quality, meeting all A.W.W.A. standards. When and where you use it, the services of Barrett's Service Representatives are available. These highly trained, experienced pipeline engineers assist you from the planning stage right through to the application of Barrett coal-tar enamels.

Here are the 10 special advantages of Barrett Waterworks Enamel:

• *Rigid quality control* • *Prevents tuberculation and incrustation of interior pipe surfaces* • *Effectively protects external pipe surfaces* • *High ductility and flexibility, high resistance to soil stresses* • *Unusual tenacity* • *Effective under all kinds of climatic conditions and topography* • *Quick service* • *Wide availability* • *High dielectric properties* • *Impermeable to moisture, non-absorptive, non-porous*

Barrett Division, Allied Chemical & Dye Corp., 40 Rector St., N. Y. 6, N. Y. In Canada: The Barrett Co., Ltd., 5551 St. Hubert St., Montreal.

CENTENNIAL 1854 1954 Barrett

BARRETT PROTECTIVE COATINGS

How to Locate Water Leaks

WITH SIMPLEX PITOT EQUIPMENT

WHY not decrease your load and stop pumping to waste? Locate the hidden leaks which waste thousands of gallons per day per mile of main . . . far more than usually guess-timated!

Locating these leaks with Simplex Pitot Equipment costs only a tiny fraction of the value of the water being wasted. You get accurate flow records with minimum effort . . . valuable data that will help you to reduce "unaccounted-for water" to a minimum.

PITOT ROD

Simple, rugged and lightweight. Easily installed on any pipe or main. Special clamp holds tube firmly in position against water pressure.

Low coefficient gives high differential pressure for greatest accuracy.

MANOMETER

Quickly connects to a Simplex Pitot Rod with flexible tubing. You then have a simple, sensitive and inexpensive instrument for indicating rate of flow.

Can be used for wide flow ranges . . . low or high.

PITOT RECORDER

Connects easily to Pitot Rod. Eight-inch chart records flow data. Simple and rugged construction . . . no delicate mechanisms . . . yet sensitive and accurate.

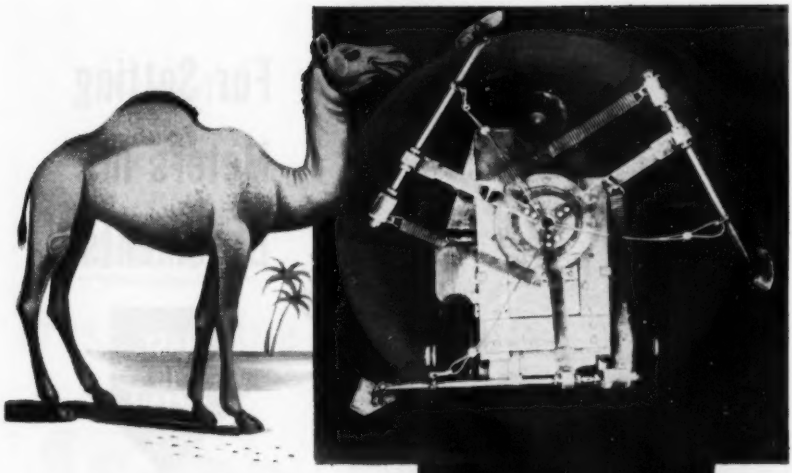
Sturdy carrying case. Leveling feet. Reliable 7-day clock movement for chart. Accurately calibrated.

Get the Facts!

Free 20-page Technical Bulletin 1300. Full instructions for use and care of Pitot equipment. Seven pages of helpful formulae, tables, curves. Write to Simplex Valve & Meter Co., 6784 Upland St., Philadelphia 42, Pa.

SIMPLEX®

VALVE AND METER COMPANY



CENTRILINE goes to Aden

Deep in the middle east, Centriline is currently centrifugally lining 11,920 feet of salt water mains for the Anglo Iranian Petroleum Company's Aden Refinery. The mains vary in diameter from 24" to 74" and are being lined with cement mortar in thicknesses of from ⅜" to ¼". The General Contractor, George Wimpy & Co. of England and the Pipe & Erection Contractor, Bechtel International Corp. of San Francisco, selected the Centriline process for the same reasons that have made it famous across the United States . . . guarantee against interior leakage, corrosion and tuberculation . . . low pumping costs . . . and high carrying capacity. Whether old or new, when a pipe is Centrilined its life is extended indefinitely. For complete details, call on Centriline today.

3,000,000 FEET OF EXPERIENCE

CEMENT-MORTAR LINING OF PIPES IN PLACE

CENTRILINE CORPORATION

A subsidiary of Raymond Concrete Pile Co.

140 CEDAR STREET • NEW YORK 6, N.Y.

Branch Offices in Principal Cities of United States and Latin America

For Setting Meters in Basements

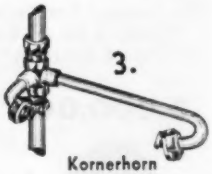
EASY TO INSTALL

The KORNERHORN

In a vertical basement pipe, against the wall or in a corner, the Kornerhorn makes a most satisfactory meter setting. Installation is fast and economical as pipe threading is eliminated. Send for detailed information.

1. Cut supply line. Clamp not necessary but convenient

2. Add Connections



3. Kornerhorn in place

When Valves are Needed

Ford Kornerhorn valves installed on the supply side, or on both sides of the Kornerhorn add extra convenience and cleanliness when meters are changed.

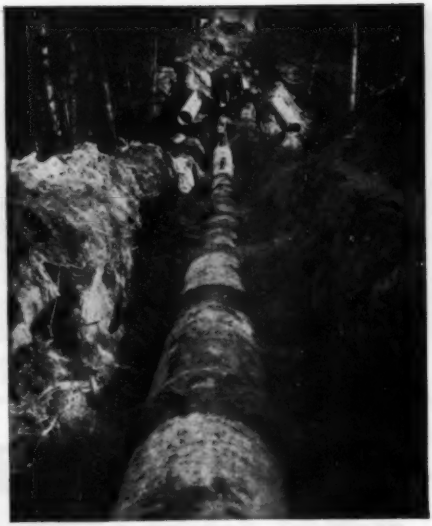
THE FORD METER BOX COMPANY, INC.

FOR BETTER WATER SERVICES

Wabash, Indiana

FORD

Norfolk Prefers Concrete Pressure Pipe



Since 1921, Norfolk, Virginia, has been specifying concrete pressure pipe for its water supply and distribution system. Over 450,000 feet of pipe is now in use. Diameters range from 20" to 48".

Still in excellent condition is the 31,700 feet of concrete pressure pipe laid in 1921. There has been no necessity to take this pipeline out of service for any maintenance work; nor has the pipeline suffered from any trouble due to electrolytic action. This pipe is now carrying water at the same high capacity as when it was installed.

If your city wants pipe with an assured high-carrying capacity, decade after decade...if long term economy is a necessity . . . then look into the advantages of concrete pressure pipe when you plan your next transmission or distribution lines.

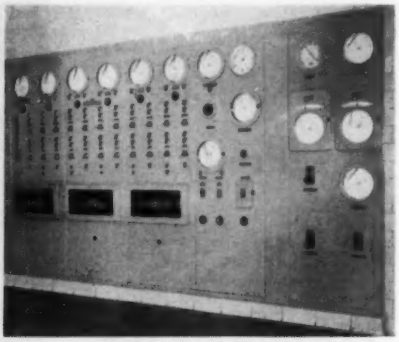
Member companies manufacture concrete pressure pipe in accordance with nationally recognized specifications

Concrete PRESSURE Pipe

WATER FOR GENERATIONS TO COME

AMERICAN CONCRETE PRESSURE PIPE ASSOCIATION
228 North LaSalle Street
Chicago 1, Illinois

Aldrich Purification Units and Filters at Alexandria plant of American Water Works Service Company.



Central control panel from which effluent and backwash rates are remotely controlled by Builders Auto-Central Control.

HOW BUILDERS *AUTO-CENTRAL* FILTER CONTROL REDUCES COSTS . . .

The same type of automatic time-sequence operation which has won such wide acceptance for automatic home washing machines now comes to the modern water works. Here is one of the first installations of Builders Auto-Central (automatic-centralized) filter Control, proven by over three years of successful operation at the Alexandria Water Company in Alexandria, Virginia.

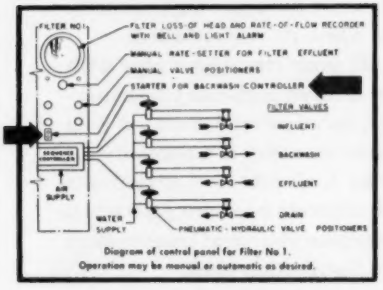


Diagram of control panel for Filter No 1.
Operation may be manual or automatic as desired.

Auto-Central Filter Control is another example of Builders' pioneering in the water works field. For complete details on this or other types of Builders Water Works Equipment, write Builders-Providence, Inc. (Division of B-I-F Industries, Inc.), 365 Harris Ave., Providence 1, R. I.

Builders Auto-Central Control has many advantages: It saves time — relieves plant personnel for other duties. It eliminates supervisory headaches. It insures accurate backwash rates, proper washing times, and helps to maintain maximum filter efficiency. It reduces construction costs by eliminating the need for shelter over conventional operating tables.

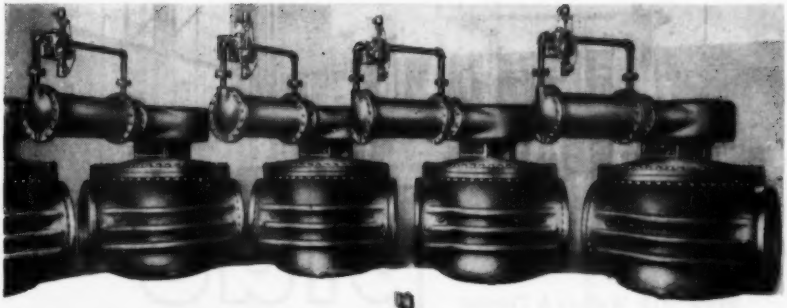
Here's how Builders Auto-Central Control backwashes a filter: A Builders Loss-of-Head Gauge signals the need for filter backwashing. The pumping station operator (there's only one per shift!) pushes a button which starts the backwash cycle for the proper filter. The Sequence Controller and Pneumatic-Hydraulic Valve Positioners then complete the washing cycle step by step, and return the filter to normal operation TOTALLY UNATTENDED.

BUILDERS-PROVIDENCE

DIVISION OF B-I-F INDUSTRIES, INC.

BUILDERS IRON FOUNDRY • PROPORTIONEERS, INC. • OMEGA MACHINE CO.

BIF METERS FEEDERS CONTROLS



. . . 52 of these
CHAPMAN
Automatic Cone Valves
supplied for TVA

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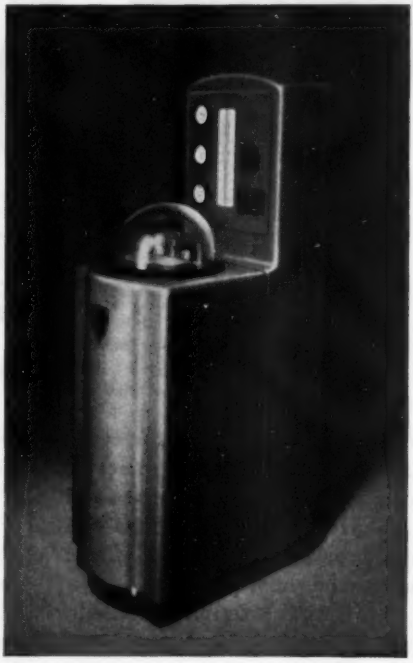

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Journal
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Resources of the Pacific Northwest

By Fred Merryfield

A paper presented on May 24, 1954, at the Annual Conference, Seattle, Wash., by Fred Merryfield, Prof. of San. Eng., Dept. of Civil Eng., Oregon State College, Corvallis, Ore.

THE Pacific Northwest is a land bounded on the east by the Rocky Mountains, on the south by the Great Basin, on the west by the Pacific Ocean, and on the north by the Canadian Rockies (Fig. 1). The area is traversed by the Coast and Cascade ranges running roughly parallel to the coast through Oregon and Washington and into British Columbia. Between these chains lie the Willamette and Cowlitz valleys and the Puget Basin. Coastal rivers drain directly to the sea, while, east of Seattle and Tacoma, Wash., the western Cascade rivers drain directly into Puget Sound. To the north, the Fraser-Thompson river system drains inner British Columbia, flowing through the Coast Mountains to Vancouver, B.C. The large plateau of the Columbia Basin, comprising most of eastern Washington, receives drainage from Montana, British Columbia, and northern Idaho. The Columbia River, passing through one of the world's most impressive gorges, forms the boundary between Oregon and Washington.

The Snake River, rising in Yellowstone National Park in northwestern Wyoming, drains southern Idaho, turns north to form the Idaho-Oregon boundary, and then swings west to meet the Columbia in south central Washington. The high plateau lands of central Oregon are drained by two splendid rivers, the John Day and the Deschutes, flowing northward into the Columbia. South central Oregon is drained partly by the Klamath River, which cascades through northern California. The Great Basin section of south central Oregon has no outlet. This large area of prehistoric lake beds is being reclaimed for bird and animal sanctuaries.

Climate has a profound influence on the life and work of the people. The winds are direct from the Pacific, except when cold blasts from the northeast cross the area. The moist temperate winds from the Pacific Ocean

are intercepted by the Coast Range, where an annual precipitation of 120 in. has been recorded in the rain forests of the Olympic Range. On the lee of these mountains, in the populous Puget Basin and Cowlitz and Willamette valleys, the annual precipitation averages 30–40 in. The higher Cascades wring out another 70 in. per year, and the rainfall on the plateau to the east drops to as low as 7 in. The Blue, Bitterroot, Sawtooth, Seven Devils, and similar mountains in Oregon, Montana, and Idaho produce about 20–30 in. of snow and rain a year, the Rockies receiving most of their moisture in the form of snow.

The mountains of the area east of the Coast Range are covered with snow. Elevations of the Coast Range are below 5,000 ft, while the Cascades have peaks, such as Rainier, St. Helens, Baker, and Hood, which are between 10,000 and 14,000 ft above sea level. The arid high plateau of eastern Oregon and Washington is between 2,000 and 5,000 ft. The eastern boundaries of the region rise to 11,000 ft.

River Systems

The Columbia, a giant, clear river, has a low flow of 37,000 cfs, a maximum of 1,200,000 cfs, and an annual mean of nearly 200,000 cfs at The Dalles, Ore. This large flow, combined with the great drop in elevation throughout the length of the river and its tributaries, provides a source of vast potential hydroelectric power.

The development of the Columbia River system and the other rivers of the Pacific Northwest for power, irrigation, domestic supply, and navigation has led to a great use of water throughout the area. The annual average power output is approximately 4,500,000 kw, serving a population of more than 4,500,000. Only a minor part of this power is obtained from steam. It has been estimated that an additional 250,000–500,000 kw will be needed each year to keep up with the demand in the next decade. The average yearly electrical-energy use per home in this region is 5,000 kwhr. The river also furnishes many thirsty acres with irrigation water, is a source of domestic and industrial water supplies, acts as a passageway and habitat for anadromous fish, serves as a waterway for ocean-going vessels, and provides unparalleled recreational opportunities.

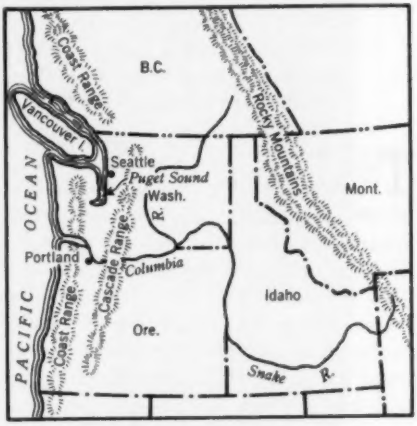

Fig. 1. Pacific Northwest Region

Many of the famed rivers of the west are tributary to the Columbia, including the McKenzie, Willamette, Deschutes, Yakima, Cowlitz, Snake, Salmon, Clear Water, Spokane, Kootenai, Okanogan, and Clark Fork. These streams drain the ancient lava fields of the desert plateaus, the cool peaks and lakes of the timbered mountains, and the ice fields of the glacier country. Into Puget Sound pour the Skagit, Skykomish, Snohomish, and

Nisqually; and into the sea, from north to south, tumble the Hoh, Quinalt, Chehalis, Nehalem, Nestucca, Alsea, Siuslaw, Umpqua, and Rogue—the latter, less than 120 miles long, rising near fabulous Crater Lake at el 6,000. The Cascades were not misnamed.

Land Resources

There is approximately 96,000,000 acres of forest land in the Pacific Northwest, exclusive of British Columbia. About 70,000,000 acres can be classed as commercial forest, of which 25,000,000 are in the Douglas fir belt and 45,000,000 in the pine belt east of the Cascades. The volume of saw timber is in inverse proportion, owing to the effect of rainfall and different growing conditions. The estimated volume of Douglas fir timber is 500 billion board feet. The major owners of this are the lumber industry and the federal government, with state, city, and county managing nearly 10 per cent.

Timber cutting and losses from fire and insects remove almost 3 billion cubic feet a year, while new growth adds 1.8 billion. With improved logging operations, fire control, management, and tree farming, the sustained yield may approach 3 billion cubic feet. Better managed forests and tax reforms may eventually prevent the disaster that overtook the forests of other regions. Research on insect control and better waste wood utilization point to a brighter picture, although much remains to be done.

The range lands of the west are famed in song and film. Half of the area of the Pacific Northwest section is devoted to the production of livestock and contributes much to its economy. In the sagebrush grass area of southeastern Oregon and southern Idaho, the spring-fall ranges serve as pasturage for cattle and sheep. Other types of range grass in the higher mountains to the east support livestock in the summer. In Idaho and northwest Montana, off the highways, the cowboy and sheepherder, with dogs and chuckwagon, still keep a lonely vigil under a starry sky.

Approximately 11 per cent of the 185,000,000 acres of land in the Pacific Northwest is devoted to crops. Dry farming in central Oregon, eastern Washington, and northern and southeastern Idaho produces vast quantities of wheat and peas, aided by improved mechanization, tillage, and packaging. In the irrigated valleys of the almost arid sections east of the Cascade Mountains, in southeastern Oregon and central British Columbia, are grown some of the finest fruit, vegetables, flowers, and berries on earth. The irrigated valleys of the highlands provide the many grasses and hay needed for bringing livestock to maturity.

More than 4,500,000 acres of land is irrigated, 90 per cent of it east of the Cascades, in Washington, Oregon, and Idaho. The use of thin-wall aluminum tubing and low-cost power is rapidly increasing sprinkler irrigation. The large irrigation development near Grand Coulee will eventually transform the face of a million acres of sagebrush.

The diversified farming of the Willamette, Cowlitz, and Puget Sound areas is almost tripled by supplemental irrigation, which offsets the dry summers in this region. Because of these dry summers and the semirural character of the smaller towns, the domestic water demands are high during peak hours. A recently completed study of some Oregon cities indicates a maximum monthly consumption of 300–600 gpcd.

Mineral Deposits

Mineral deposits, the third most important product of the region, are located primarily in western Montana, northern and central Idaho, northern Washington, and southwestern Oregon. The greater share, however, exists in Montana and Idaho. Copper, lead, zinc, silver, and gold have been mined and smelted, and have contributed largely, particularly in the early days, to the area's prosperity. The aluminum-reduction industry has grown rapidly, owing to the availability of cheap power.

Coal—mostly lignite, subbituminous, and noncoking types—has been mined in the Cascade region of Washington and the coastal section of Oregon. The phosphate rock of southern Idaho and western Montana will eventually add to the value of mining and agricultural production. Deposits of iron, tungsten, manganese, chromite, and antimony also exist, but to date lie undeveloped, awaiting a larger population. The electrochemical industry grew rapidly during the war and will continue to do so with available power and markets. In general, the mineral resources of the region need more exploration and exploitation.

Transportation and Fishery

The rivers and the sea have always furnished highways to the people of the Pacific Northwest. The railroads followed the main streams or cut through the Rockies and Cascades in spectacular passes. Epic tales are told of the Irish, Swedish, Hungarian, American, and Chinese gangs that drove the rails through difficult terrain to Seattle, Portland, and Vancouver. The highways followed, the great and very scenic 300-mile Columbia River Highway (now part of US 30) being built in 1913. Small populations and long distances have made highway building difficult, and the mountain ranges and rivers of the Pacific Northwest have added considerably to the cost of development. Improvements are being rapidly constructed to handle the very heavy traffic problem. Many small towns are isolated from railroads, making automobile and bus transportation essential. Freight rates and costs have a very decided effect on the economy of the region.

The sea and the rivers add to both the economic and recreational resources of the Pacific Northwest. The ocean furnishes salmon, halibut, pilchard, albacore, tuna, cod, oyster, and crab. In 1940, in the Pacific Northwest, British Columbia, and Alaska, approximately 170,000 tons of salmon, or 7,000,000 cases, were packed. Oregon and Washington accounted for about 10 per cent of this figure. The oyster and crab industry of the Puget Sound area contributes much to the delight of epicures and the economy of many families.

Recreational Resources

The rivers and lakes also furnish sport and retreat from daily cares. One can cast a fly in the mountain streams and refresh the soul, as well as the body. A fine system of public parks and camps makes this recreation available to all. Pollution, once a great danger to the area, is now being abated by a wholehearted effort on the part of cities, industry, and, to a lesser extent, logging and mining companies. Since the war much has been accomplished to reclaim the waters for sport fishing. Improved river management and fish culture point to a continuance of this healthful pleasure.

In the forests of the coast and the mountains of the interior, the deer,

antelope, elk, bear, bobcat, cougar, and coyote are a hunter's delight. The drumming of grouse on an old rotten log and the raucous crow of the China pheasant are heard at morn in many an urban garden, and occasionally bands of geese blacken the sky, the air filled with their honking.

In spite of past abuse, there is a growing appreciation of the intrinsic values of the open spaces, the forest glens, the mountain lakes and streams, the productive valleys and rolling hills, the island inlets and coves, and the never calm sea. These resources provided by nature and blessed by the western breeze give the people of the Pacific Northwest shelter, food, raiment, light, beauty, and renewal of faith in one another.

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Seattle Plans for the Future

By Allan Pomeroy

An address presented on May 24, 1954, at the Annual Conference, Seattle, Wash., by Allan Pomeroy, Mayor, Seattle, Wash.

SEATTLE, the site of AWWA's seventy-fourth Annual Conference, has changed a great deal in 74 years. In 1880 the total population of the state of Washington was 75,000, of which Seattle had slightly over 3,000. The first rail connection to the East, via Portland, Ore., had been completed the year before. The next two decades saw the completion of the Northern Pacific Railroad to Puget Sound, in 1883; the completion of the Great Northern, in 1893; and the Alaska gold discovery, in 1897. In 1900 Seattle was jammed with 90,000 people—a 30-fold increase in 20 years. The next 10 years witnessed a frantic, furious outburst of planning progress and action. The population of the city much more than doubled during the first decade of the twentieth century, reaching 237,000 in 1910.

Hills were removed, steep grades ruthlessly regraded, hundreds of acres of evil smelling tide flats filled. Parks were created, extended, and connected by boulevards. Large areas were annexed, the streetcar lines were rapidly extended to the new limits, and interurban lines linked a rapidly growing "Suburbia" to the city proper.

Urbanization and Automobiles

The 1910 census revealed two major changes in the American scene. These have had and continue to exert a profound effect upon the United States and Canada. For over 100 years each successive census had shown a greater urban than rural population growth. But when, in 1910, the figures revealed a slightly greater total urban * than rural population, the outcry was startling. Spearheaded by Theodore Roosevelt, a great movement to keep people on the farm was begun. Many serious predictions foretold the death of the Republic: huge city mobs of undisciplined sweatshop workers would shatter the established political institutions, which had been developed for and by a population that was 95 per cent rural (the overwhelming majority being farmers) and only 5 per cent urban.

The other startling statistic of 1910 was that 181,000 automobiles and 6,000 trucks had been manufactured in that year, nearly eight times the 24,000 total for 1905. In the opinion of many business leaders, this marked the high point of the automobile craze, which would now go the way of the bicycle fad of the 1890's. It was argued that everyone who could possibly afford an automobile had one—and, alas, some who could not afford one. Besides, the things were noisy, they frightened the horses, and they smelled of oil and gasoline. Not only that, tires were so poor that twenty punctures in 20

* Incorporated places with 1,000 or more persons.

miles was not unheard of, and the roads didn't get you anywhere, anyway.

According to the 1950 census returns, the adult population of Washington was 1,023,528 urban, 370,789 rural but not farm, and 164,949 farm. The traffic people tell me that 200,000 cars and trucks are registered within the city limits of Seattle—more than the entire national production of 1910. These points are not brought out to belittle the thinking capacity of the leaders of 40–50 years ago. They were confronted with conditions for which no prior standard of comparison existed.

The development of a vast *private* transportation system, geared to the population shift to the cities and their suburbs, poses a great political problem entirely different from that which worried the social thinkers of 1910. Generally, an attempt has been made on a small scale to solve this problem by the formation of municipal districts for a specific purpose, such as water, sewer, fire, school, park, road, or irrigation service. The metropolitan authorities so far established have generally overlapped city corporate limits and have been largely confined to parks, roadways, water, and sewerage functions.

Intergovernmental Relationships

The Seattle planning problem is only one phase of an area problem which is equally vital to the city. Washington has an area of 68,192 sq miles. Seattle is the center of the Puget Sound strip, which runs 60 miles north and south and averages 10 miles in width. This 600 sq miles, less than 1 per cent of the total state area, contains approximately half the population of the entire state. It crosses the boundaries of three counties, three port commissions, more than twenty incorporated cities, large and small, plus more than 200 special municipal districts, as well as state and federal jurisdictions.

It is significant of the thinking of the founding fathers that nowhere in the Constitution or its amendments can the words "city" or "town" be found. One of the dramatic decisions of the Constitutional Convention was to build a capital city, but the Constitution simply confers on the Congress the power of "exclusive legislation over such district as may become the seat of Government." This absence of any reference to cities or towns seems odd, because the first English parliament convened called two burgesses from chartered towns, as well as two knights from each shire. The system of town charters granted by the crown and enjoying parliamentary representation was still operating in England when our Constitution was written.

A number of direct relationships now exist between the cities and the federal government. Certain federal highway and bridge funds are available to cities on a matching basis. Certain slum clearance and city rehabilitation funds are also available. In December 1953 the President himself told the Mayors' Conference on Civil Defense that the "cities now constitute the first line of defense." A very recent release from the federal civil defense director strongly indicates that serious consideration is being given to a request by a group of mayors, of which I am one, to effect a direct relationship between the cities of America and the Federal Civil Defense Administration.

So we can see that, in our planning, we may have an unexpected resource in far larger federal participation than seemed possible only a few years ago. I am not suggesting for one moment that I would welcome any form of federal direction. But, inasmuch as federal tax revenues greatly exceed those of state, county, and city, it seems only fair that a greater portion should be available at the local level.

The following examples of Seattle's planning are not intended to indicate the scale or magnitude of the individual projects but rather to suggest the variety of methods adopted. In the ten months from Mar. 1, 1953, to Jan. 4, 1954, the city annexed two areas of about 10 sq miles each, contained a total population estimated at 45,000–50,000 persons. Fortunately our water, light, and health departments were already serving these areas. But the other city departments certainly had, and still have, plenty of problems in extending their services to so large an additional area and population. In this instance, the planning was almost completely a product of the departments and their separate staffs.

In terms of water supply, our plans are well advanced. The story of our Cedar River watershed and the development of water department operations is available to you.* I would like to point out, however, that the water, light, and engineering departments are surveying the Cedar River watershed with a view to the construction of new dams to increase the water supply for our city reservoirs and the hydroelectric power from our plant at Cedar Falls. Exploratory surveys by aerial photomapping, in addition to conventional ground operations, are currently under way in the Tolt River watershed. These are a joint responsibility of our water and engineering departments.

A major planning proposal now being considered is the formation of a Puget Sound planning council. This contemplates a staff to record at a central office all proposed plans of all planning groups in Pierce, King, and Snohomish counties. The area of these three counties is approximately 7,000 sq miles. The densely populated portion is the 60 × 10-mile strip previously mentioned. Port commissions, county and municipal officials and planning commissions, school districts, and similar organizations have been invited to send representatives to the proposed council. It is hoped that, by this means, greater correlation in planning can be obtained. It is further hoped that certain conflicts can be avoided.

Electric Power

Hydroelectric power has been the cornerstone of the new industrial development of the Pacific Northwest. At present any further development of the hydroelectric potential by the federal government seems highly problematical. Seattle is in the power business in a big way. We have over $200,000,000 invested in dams and generating and distribution facilities. The light department's annual sales reach $30,000,000. Of approximately 185,000 homes in the area served by city light, 161,000 have electric ranges in the kitchens. The statistics on other home uses of electrical power—from hot-water tank heating units to hedge shears, lawn mowers, and power tools for home workshops—are fasci-

* Seattle watershed management is described in the panel discussion beginning on page 723 of this issue.

nating but frightening. They are frightening because the inevitable increase in power consumption for home, commercial, and industrial use will require an estimated 1,600,000 kw of additional power during the next 10 years to supply the Puget Sound region. The estimated capital requirement for production and distribution facilities is over $500,000,000.

Here was a planning problem beyond local capacities. On Apr. 14, 1954, the formation of the Puget Sound–Cascade Utilities Council was announced. So far as can be learned, the structure of this council has no counterpart in American history. The Utilities Council is composed of five units. The Seattle and Tacoma light departments are municipal operations having both generating and transmission facilities, and having a power monopoly in their respective service areas. The Snohomish County and Chelan County public utility districts are municipal corporations of the special-service type, but operate over larger areas than usual. (The Chelan County district has both generating and transmission facilities. The Snohomish County district buys all its prime power and is engaged at present in distribution only.) The fifth unit in the Utilities Council is the Puget Sound Power and Light Co., a large private corporation with several generating plants and extensive transmission facilities in most of the eight counties bordering Puget Sound. All five components of the Utilities Council have a history of maintaining exceptionally strong financial positions. All are highly regarded in major bond markets.

On Apr. 22, 1954, the Utilities Council issued a "Declaration of Objectives." It first points out the "exceptional prospects for rapid and diversified growth"; the need for "adequate low-cost power"; the past "insufficiency of power supply and recurrent shortages"; the member units' "special community of interest because of geographical location, common operating problems, and certain contractual relationships"; and the need for "charting a comprehensive, coordinated resource development program." The declaration then makes six specific statements, of which two deal exclusively with planning:

> These utilities agree it is their responsibility to take care of the total electric power needs of the Puget Sound–Cascade area for all purposes—including its industrial growth—*and they intend to do so.*
>
> These utilities agree to explore ways and means as to how—on a broad basis—they can best foster an expansion of the economy, aid in the creation of more jobs and larger payrolls, and help achieve the exceptional industrial and other growth potentials which the Puget Sound–Cascade area possesses.

Meeting Popular Needs

Space does not permit even brief mention of other important planning programs that are directly or cooperatively a responsibility of municipal officials. These include such items as schools, recreational facilities and programs, cultural centers and programs, waterfront facilities, airports, and many other aspects of our present way of life.

It seems completely evident that the people have demonstrated the "way of living" they intend to follow. The 1910 concept of compact housing units—apartment centers with above-average

light, air, and open-space provisions—economically served by all municipal functions whether publicly or privately operated; the concept of rapid transit by rail, and open-country areas for the small percentage demanding greater "elbow room" for living; the concept of mass transportation within the city as being most economical for the city—all these, and the associated concepts, have been generally rejected by the people themselves during the last 40 years.

The farm population did not stay on the farm as recommended. The automobile craze did not join the bicycle fad of the nineties.

The latest US Dept. of Agriculture calculations estimate the farm population at 17 per cent of the total. Who can say what further farm mechanization will do to reduce still more the percentage of our people required to produce food and fiber products to supply the nation? But surely there can be no further exodus from farm to city comparable to that of the past five or six decades.

The people of Seattle did not stay put in a tight little area of a relatively few square miles, nor did they remain dependent upon the public transportation system. Instead, they have settled nearly 300 sq miles, of which the city limits include but 90. They have invested at least $200,000,000 in private transportation, as against a mere $10,000,000 in the public transit system.

In planning the extension of municipal services and facilities of all types to meet this new condition, the new "way of life" which has developed, I am not at all distressed by the great numbers of persons engaged in official and unofficial planning. It is my firm belief that the people, with their homes and private transportation, have spoken more effectively than any polling of votes could have determined.

In Seattle, therefore, we are using every possible element of city department resources, singly and in combination. We are joining with other governmental units. We have even invented a new combination of public and private ownership to meet the need for additional power. These are but highlights of the methods by which Seattle plans for the future.

Watershed and Reservoir Control in the Pacific Northwest

Panel Discussion

A panel discussion presented on May 24, 1954, at the Annual Conference, Seattle, Wash.

THIS panel discussion deals with the watershed and reservoir problems and practice of six Pacific Northwest communities: Medford and Portland, Ore.; Bremerton, Seattle, and Tacoma, Wash.; and Vancouver (Greater Vancouver Water Dist.), B.C. The topics covered include: a brief historical description, land ownership, forestry and logging operations, sanitary protection and policing, public entry for recreation, and algae and weed control. A map giving the general location of the various cities is shown in Fig. 1. Figures 2–12 illustrate portions of the watersheds involved.

Historical Development—*George A. Marshall*

A paper presented by George A. Marshall, Supt., Bureau of Water Works, Portland, Ore.

Medford

Medford derives its water supply from a series of springs located near the summit of the Cascade Range, approximately 30 miles northeast of the city. Breaking out from under a lava cap at Big Butte Springs, the waters are collected in concrete galleries and diverted into two steel pipelines that transport a total of 24 mgd to the city distribution system.

The fan-shaped watershed that contributes to the flow of the springs forming Big Butte Creek has its apex at Mount McLaughlin, approximately 10 miles southeast of the stream. The elevation of the springs is 2,665 ft, while the McLaughlin peak is 9,200 ft high. The winter snows that accumulate on the mountain percolate through the lava, and the water emerges at the springs. No surface streams exist on the mountain slopes or in the watershed itself, except for Willow Creek on the west watershed boundary and Fourbit Creek on the east boundary.

In order to satisfy the existing water rights of an irrigation district on Big Butte Creek, it was necessary for the city to provide an impounding reservoir. Its 7,500 acre-ft capacity enables the city to use all the fresh spring water when needed and to make up the irrigation district's share of the stream flow from storage.

Portland

In 1892 a presidential proclamation set aside as a public reservation an

area of 218 sq miles within which lies the Bull Run River watershed, on the western slope of the Cascade Range. Above the diversion point, this watershed has an area of 102 sq miles, at elevations between 750 and 4,700 ft. The area is very rugged and heavily forested, and the underlying formation is composed of various volcanic flows. The main branch of the river has its source in Bull Run Lake, which lies close to the summit of the Cascades, 7 miles northwest of Mount Hood, at el 3,175. No glacial water from Mount Hood can enter the watershed, because the Sandy River and the west fork of the Hood River lie between the two. The lake is 1¾ miles long and ¾ mile wide, with a storage capacity of 3 bil gal. Since January 1895 a gravity water supply has been obtained by Portland from the Bull Run River. The average flow of the river at the headworks is 812 cfs, with a maximum flood flow of 21,000 cfs and a low flow, in late summer, of 64 cfs. A concrete gravity dam, 200 ft in height and 950 ft in crest length, was completed in 1929 at a cost of $3,000,000. This dam provides a storage volume of 11 bil gal.

The storage reservoir extends 3½ miles along the river. A 40-ft high gravity diversion dam, located 5 miles downstream from the storage dam and 30 miles east of the city, diverts the water into three steel conduits that carry it to two reservoirs on Mount Tabor (el 411.6).

Bremerton

Bremerton has been served by a public water supply since 1902. The water system was purchased by the city from private interests in 1917 for $225,000. At present surface supplies are derived from four watersheds, and additional water is obtained from seven wells developed during World War II. A total of 15 mgd is available. Charleston Creek, a small stream flowing southeast and emptying into Sinclair Inlet about 2 miles from the city, was the first source. A log crib dam built in 1902 provided 1 mil gal of storage. In 1938 the dam was raised, and excavation above it increased the amount of storage to 7.6 mil gal.

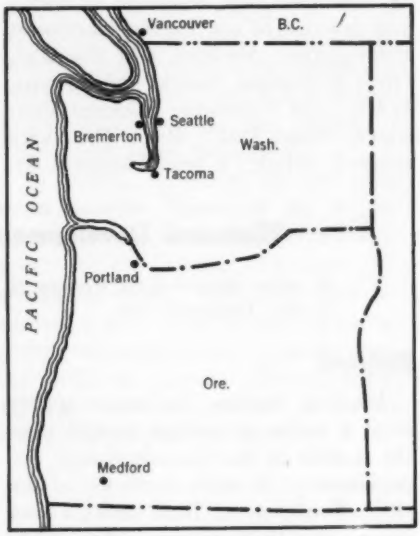


Fig. 1. Location Map

Anderson Creek, flowing north and entering Sinclair Inlet a mile south of the mouth of Charleston Creek, became the second source in 1905. Crib dams on two branches of the stream provided 1.5 mil gal of storage. Gorst Creek, flowing east into Sinclair Inlet, about midway between Charleston and Anderson creeks, was drawn on in 1911, when a pumping station was con-

structed about half a mile from the mouth of the stream.

Water rights for 10 mgd were filed on the Union River in 1930. Its watershed is adjacent to that of Gorst Creek, and surveys indicated that water could be piped from the Union River to the Gorst Creek station. In 1938, in cooperation with the WPA, a diversion dam was built on Union River above McKenna Falls, and a pipeline was laid from the dam to Twin Lakes, in the Gorst Creek watershed. The banks of the lakes were cleared, and they were deepened to 55 ft to permit 250-mil gal storage. It is planned to provide 2 bil gal of storage by constructing dams in the Union River Canyon. To improve the system further, the city is presently constructing a new 2.3-mil gal distribution reservoir in Forest Ridge Park.

Seattle

In 1890 the citizens of Seattle elected to operate their own municipal water system, and the city purchased the properties of the Spring Hill Water Co. This company, serving the major portion of what then was Seattle, pumped its supply from Lake Washington. Other parts of Seattle were then being supplied by privately owned wells and springs. These small systems were acquired by the city and brought into the municipal system within the next few years. At the same time plans were made for securing a gravity supply from the Cedar River. Since 1901 that stream has supplied all the water for the city.

The Cedar River rises in the mountainous region forming the crest of the Cascade Range in eastern King County. There the streams flow swiftly through narrow, steep-sloped valleys, with the flanking ridges rising to 5,500 ft above sea level. Approximately 13 miles from the river source is Cedar Lake (el 1,530), a large natural lake, 4½ miles long and ½ mile in breadth, which completely fills the valley floor. Below the lake there is a descent of 600 ft in the next 2 miles, beyond which the valley broadens, with a gradual drop to the intake at Landsburg (el 535), about 23 miles from Seattle.

The term "Cedar River watershed" has come to denote all the drainage area of the Cedar River above the Landsburg intake. The watershed is roughly rectangular, extending eastward from Landsburg for 25 airline miles and up to 8 miles in width. It has an area of 143 sq miles, or 91,500 acres. At the Landsburg intake, the Cedar River has an average flow of 692 cfs, a maximum flood flow of 13,600 cfs, and a minimum late-summer flow of 83 cfs. Control and regulation permit a sustained withdrawal of 300 mgd by the city.

The storage capacity of Cedar Lake and the 600-ft drop in the Cedar River at Cedar Falls was developed by the city into the Cedar Falls Power Plant, the genesis of the present municipally owned light and power system, which started originally as a division of the water department but later attained independent departmental status. The present installed capacity is 30,000 kwhr. In 1904, as part of the power development, a rock-filled timber crib dam was constructed at the outlet of Cedar Lake, raising its level by 18 ft and providing 16,000 acre-ft of storage. A concrete dam, built a mile downstream from the crib dam in 1914, raised the lake level to 30½ ft

above the original level and provided a storage volume of 57,000 acre-ft. Power production alone no longer governs the regulation of storage in Cedar Lake. During the summer it is necessary to release water from it in order to provide a flow at the Landsburg intake sufficient to meet the demands for water. Studies and plans are now being made to develop further storage in Cedar Lake and to eliminate as much seepage loss as possible.

The present headworks system at Landsburg consists of a low concrete diversion dam (el 535), having an overflow section topped with Tainter gates for regulation. The headhouse at the dam is equipped with trash racks, gates, and movable screens to eliminate debris of any size. From the screen chamber and forebay, the water flows through a 96-in. ID concrete conduit, which, after 2½ miles, branches into two 78-in. pipelines extending ap-

Fig. 2. Mount McLaughlin (Medford)

The winter snows that accumulate on this mountain are the principal source of Medford's water supply. The foreground is typical of the forest cover on the watershed.

proximately 6 miles to Lake Youngs (el 488.8). This lake, the primary storage reservoir for Seattle, has a capacity of 3,660 mil gal.

When the Cedar River is running clear, with no measurable turbidity, Lake Youngs can be bypassed and the water sent directly to the control works. This practice, usual during the summer, is desirable because the temperature of the river water is much lower than that of the lake water. At other times Lake Youngs also serves as a sedimentation basin, except when the turbidity of the river exceeds 5 ppm. On such occasions withdrawal from the river is suspended and the storage of Lake Youngs is drawn upon.

Tacoma

At present the Tacoma Water Div. obtains roughly 95 per cent of its annual supply from the Green River gravity system and the balance from the South Tacoma well system. The main artery of the gravity system is a pipeline that extends approximately 42 miles east from Tacoma to a diversion dam on the Green River. The dam marks the western boundary of the Green River watershed, 231 sq miles in area, which is located in the southeastern section of King County. The watershed is 25 miles long (from the diversion dam to Stampede Pass) and has an average width of approximately 10 miles. Its topography is rugged, with steep slopes and narrow valleys. Elevations range from 908.8 ft at the crest of the diversion dam to 5,380 ft at the top of Meadow Mountain, on the northeastern boundary.

The construction of the Green River gravity system was authorized in 1910, and the first water was delivered to the city in May 1913. The concrete diversion dam is 17 ft high and has a crest length of 152.4 ft. The intake gates at the north end of the dam are protected by rack bars and admit water through a short tunnel into a small settling basin, equipped with a blow-off gate and a skimming weir, which aids in diverting flood debris and maintaining a constant head on the pipeline.

Vancouver

The Greater Vancouver Water Dist. is a corporate body established in 1924 by an act of the provincial legislature and charged with supplying water in bulk to its constituent municipalities at cost. When operations began, in 1926, the district was composed of the city of Vancouver and the two adjacent municipalities of Point Gray and South Vancouver, which have since been annexed to Vancouver. At present the district has a membership of four cities and ten municipalities and supplies water to a population of almost 600,000.

The district owns and operates a number of reservoirs. Little Mountain Reservoir, located in the center of the distribution area, is used to balance variations in daily flow. This single-unit open reservoir, lined with reinforced concrete, has a capacity of 24.2 mil gal (Imp.). Built in 1910, it was acquired by the district from Vancouver in 1926. Vancouver Heights Reservoir, situated on the north side of the distribution system, is also used to balance the daily flow variations. A covered, reinforced concrete structure, it has a capacity of 7.5 mil gal, and is the first of six units of like capacity planned for this location. New Westminster Reservoir, in the northeast corner of the city of New West-

minster, was a one-unit, unlined, open reservoir of 8.1-mil gal (Imp.) capacity when the water district acquired it in 1931. Recently a second unit, approximately 12 mil gal (Imp.) in capacity, was constructed next to it. This reservoir serves New Westminster and a small portion of the adjacent municipalities of Coquitlam and Burnaby. The district also has a 2.2-mil gal (Imp.) concrete-lined open reservoir in New Westminster at an elevation lower than the two units previously referred to. This reservoir serves the city of New Westminster only. For its principal storage capacity, however, the district depends on reservoirs located in the north shore region, where mountain lakes are utilized and valleys dammed. Table 1 gives the overall characteristics of these storage basins.

TABLE 1

Vancouver Storage Reservoirs

Reservoir or Basin	Area *acres*	Capacity *acre-ft*	Year Built	How Developed
Burwell Lake*	113	12,000	1926	tunnels driven into rocky rims to tap top storage; low-level dams added later
Palisade Lake*	126	16,000	1927	as above
Loch Lomond*	105	5,300	1927	as above
Seymour Falls Balancing Res.	180	1,080	1928	dam across valley
Cleveland Storage Basin	648	48,000	1952†	high-level dam in canyon
Coquitlam Lake Storage Basin	3,000	310,000‡	1913	earth-fill dam across valley

* Utilized to supplement rivers during low-flow periods.
† Not completed.
‡ Shared with power company.

Land Ownership—*W. A. Kunigk*

A paper presented by W. A. Kunigk, Supt., Water Div., Tacoma, Wash.

Medford

All of the Medford watershed and intake facilities are within the boundaries of the Rogue River National Forest, thus assuring the city many safeguards that would be costly to acquire and maintain on its own. The region has been designated a watershed area by the federal government and is, therefore, given special consideration. The city has endeavored to purchase all privately owned tracts that have from time to time been offered for sale. The government, in turn, has made extensive exchanges with private holders and other agencies for land within this area. Eventually, it is hoped that the government and the city will have complete ownership of the watershed. At present Medford owns 2,650 acres, the federal government 18,230 acres, and private holders 580 acres. An exchange with a major lumber company that has some land in the area is now pending.

Portland

The area of the Bull Run Reserve is 218 sq miles, or 139,520 acres, of which the federal government owns 131,899 acres and the city of Portland 4,721 acres, the remaining 2,900 acres being privately owned but unoccupied. The area of the Bull Run watershed proper is 102 sq miles, or 65,280 acres, the federal government owning 62,528 acres and the city 2,752 acres.

A number of years ago the city commissioner of public utilities, through Oregon members of Congress, petitioned the United States not to dispose of any land in the reserve, but to retain it as government property not subject to entry; or else to permit the city of Portland to purchase it at $2.50 per acre (the price allowed the railway companies by the government). The city obtained some parcels of land in the reserve by purchase and by trading municipal property outside the reserve for privately owned land within it. Although the cooperation that Portland has received from the US Forest Service in patrolling and policing the reserve has been satisfactory, it is the author's opinion that the protection of

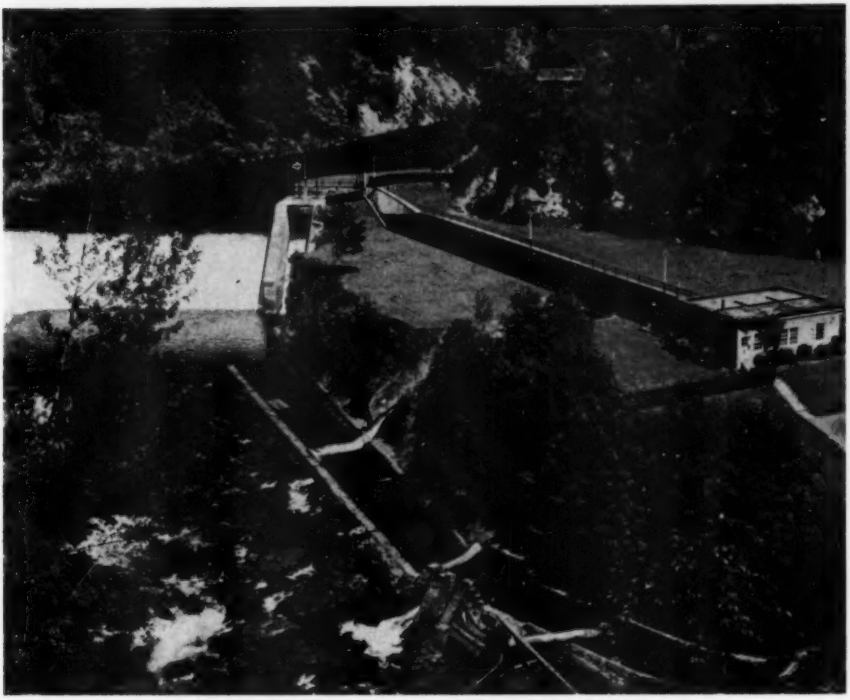


Fig. 3. Bull Run Headworks and Intake (Portland)

The average flow of the river at this location is 812 cfs.

the city water supply would be better assured if the city owned and controlled all of the watershed area.

Bremerton

When Bremerton purchased its water system in 1917 it acquired 540 acres of watershed, most of which had been denuded of timber. The wasteful methods of logging followed by the burning of slashings, with the destruction of all vegetation touched by fire, convinced the city of the need for acquiring additional watershed lands to protect its future water supply. In 1923 the city began buying property as it became available. Much of the logged-off land was taken by the county for taxes and purchased by Bremerton, and thousands of acres were bought for $7–$10 per acre from logging operators. Some of this land is outside the watershed but will be used to trade for watershed land with the State Forestry Dept. or the timber operators who are now engaged in forestry management programs to preserve the industry for the future. The city is receiving fine cooperation in this dual conservation effort.

Fig. 4. Bull Run Dam and Storage Reservoir (Portland)

A storage volume of 11 bil gal is provided by these facilities.

The present ownership of watershed lands is shown in Table 2. Approximately 4,000 acres of this land is located on a watershed to be developed in coming years. Negotiations are under way to acquire more property in this area. The capacity of the present supply is 15 mgd, and contemplated expansion will provide an additional 75 mgd. It will be the policy of the city to obtain ownership of all lands deemed necessary for the protection of the present supply and for future development.

Seattle

In 1901 approximately 30 per cent of the Cedar River watershed was publicly owned, chiefly as national forest land but also including a small acreage of state school lands. The remaining 70 per cent ranged from individual homesteads and timber claims to large holdings of timber and logging companies. A sawmill and a brick and tile factory were in operation in the watershed at that time. Seattle soon started acquiring the lands within the watershed for the purpose of protecting and controlling the water supply. The initial purchases included the areas in the vicinity of the intake at Landsburg, Cedar Lake, and the Cedar River between these two points, as well as the power rights at Cedar Falls. Later it was deemed desirable to acquire all the lands within the drainage basin. Although the most rapid acquisition occurred in the years 1905–15, it has been a continuing program, the most recent acquisition being 280 acres in the upper watershed, obtained in February 1954. Of the total 91,140 acres of watershed area, Seattle now owns 65,846; 21,463 acres is national forest; and 3,831 acres is privately owned.

Some of the watershed lands were logged prior to acquisition by the city. For most of the timbered area, the city pursued the policy of acquiring the land only, the timber and logging rights being retained by the former owners. The timber reservation agreements include such stipulations and restrictive clauses on logging operations as the city considers necessary to protect the quality of the water supply.

Under the terms of the Cedar River logging agreement, the privately owned lands will be deeded to the city without cost as rapidly as the timber standing thereon is cut. A program of land exchange between the US Forest Service and Seattle has been worked out, the city exchanging timber lands acquired outside of the watershed (as one of the considerations of the Cedar River logging agreement) for the 21,463 acres of national forest land within the watershed, after the timber on the latter has been cut. The initial exchange under this program was completed in 1953, with the city receiving patent to 2,455 acres of national forest lands. In time the city will become the sole owner of the watershed.

TABLE 2

Bremerton Watershed Land Ownership

Owner	Approx. Area *acres*
Bremerton	8,000
Port Blakely Mill Co.	500
McCormick Timber Co.	1,000
Pope & Talbot Mill Co.	1,500
Washington Forestry Dept.	1,000
School land	640
Miscellaneous owners	2,200

A perpetual easement for a power line right of way across a corner of the watershed was granted to the Bonneville Power Administration by Seattle in 1938. The city also gave a right of way to the Chicago, Milwaukee, St. Paul, and Pacific Railway in 1906, the railroad passing for 13 miles through the watershed, from Landsburg to Cedar Falls. These uses are subject to sanitary regulation by the city.

Fig. 5. McKenna Falls (Bremerton)

This steep, rugged terrain is characteristic of many of the watershed areas in the Pacific Northwest

Tacoma

The area of the Green River watershed above the intake of Tacoma's gravity system is 231 sq miles, or 148,000 acres, approximately 65 per cent lying within the Snoqualmie National Forest. A US Senate bill has authorized the addition of the remaining 35 per cent to the forest reserve. A breakdown of the ownership of the Green River watershed area is given in Table 3.

Although only a small percentage of the total is Tacoma-owned land, most of it is located near the bottom of river valleys in strategic areas, where necessary control of the surrounding region can be rigidly maintained. It has been the general policy of the Tacoma

Water Div. to acquire some of the available small private holdings along the Green River and the principal tributaries, while allowing the large lumber companies to purchase desirable timber land on the slopes. In this way, the city increases its control over possible pollution of the river without the expenditure of large sums of money in the acquisition of land. This method of watershed management has been adopted because of the magnitude of the area and the timber values involved. The ideal situation, from the viewpoint of the water department, would be complete municipal ownership of the entire watershed area. Although, under such a plan, the taxable land area of the county would be reduced, the city would gain the advantage of absolute sanitary control.

Vancouver

The Greater Vancouver Water Dist. operates three sources of supply—the Capilano, Seymour, and Coquitlam rivers—with a total catchment area of 226 sq miles. All of this area is held by the district in fee simple or under lease for a period of 999 years from the provincial government. The British Columbia Electric Co. has water rights on the Coquitlam River as well as a right of way for a transmission line over the Capilano Valley. All distribution reservoirs are located on water district property, with adequate means of protection against trespass.

TABLE 3

Tacoma Watershed Land Ownership

Owner	Approx. Area *acres*
US Government & Washington State	51,160
Northern Pacific Railway Co.	42,950
Weyerhaeuser Timber Co.	24,940
Buffelen Mfg. Co.	7,290
Tacoma	2,653
Seattle	1,400
Soundview Lumber Co.	2,240
Other small owners	15,367

Forestry and Logging—*Allen E. Thompson*

A paper presented by Allen E. Thompson, Forester, Water Dept., Seattle, Wash.

The management and utilization of the forests on the watershed areas of the six Pacific Northwest cities being discussed is of direct concern to them. The methods of handling this problem are as numerous as the cities involved.

Medford

The watershed forest of Medford is managed by the US Forest Service, the other principal owner, under a 10-year agreement. The watershed lies within the Rogue River National Forest, in which ponderosa pine and Douglas fir predominate. Early uncontrolled logging and slash fires resulted in the establishment of manzanita and buck brush on some areas, but, throughout much of the watershed, there are regions of good second-growth and marketable timber.

The land management agreement provides that the Forest Service make an inventory of the forest products in the area and develop a program of timber sales, planting, and tree pruning.

The Forest Service also makes appraisals of timber, recommends the sale of timber products, and then supervises the harvesting of the timber and the disposal of slash and other fire hazards. It also supervises and carries on tree planting and pruning of future crop trees, as well as maintaining the controls necessary to protect the forest from insects and diseases. This is an excellent arrangement for Medford, which has only a limited ownership in the watershed and no qualified personnel to administer a timber management program properly. The Medford Board of Water Commissioners is of the opinion that, with adequate safeguards, it is desirable to harvest the forest crop on the watershed. The management plan will preserve the water resources and augment the revenue of the water department by the sale of timber products.

Portland

About 54,000 acres of Portland's Bull Run watershed is heavily forested. The growth includes brush and stands of Douglas fir of varying ages. Except for water supply developments and a few roads and trails, the area is unchanged from the original wilderness. Records show that prior to 1872 some of the timber had been killed by great fires. Other information indicates that, before 1906, more than 14,000 acres of the watershed had been burned over, with another 2,000 acres burned

Fig. 6. Twin Lakes Reservoir (Bremerton)

Water diverted from the Union River, at McKenna Falls, is piped to this 250-mil gal reservoir, which was formed from two natural lakes.

between 1906 and 1914. At present the cost of fire protection is financed by both the city and the US Forest Service, with Portland's share now being $4,000 per year. There has been no cutting of timber for logging in the Bull Run watershed, and no plans for such an operation are being considered.

Bremerton

All watersheds contributing to the Bremerton supply have been completely logged during the past 80 years. Several long established timber companies are managing their properties on a basis of sustained yield. Second-growth Douglas fir is the principal timber tree on the city lands, with considerable hemlock, cedar, and alder bordering the streams. The forest varies in age up to 80 years. Several years ago a limited amount of logging of city timber was carried on, but not very successfully.

Since 1950 the city-owned forest has been managed on a sustained-yield contract between the city and a firm of foresters and timber operators. The provisions of the agreement, in addition to those governing the cutting of timber, call for the making of a forest inventory, the construction of access roads (which also serve as fire trails), the planting of trees where needed, the furnishing of suitable planting stock, and the preparation of a detailed forest management program.

Timber cutting, under this contract, has been by a selective system, with about one-third of the marketable trees removed from each section. The logs are transported to a nearby salt water booming area, where they are rafted, scaled, and then sold on bid. The city is paid stumpage amounting to 25 per cent of the sale value of the logs. During the past 4 years 900,000 fbm has been sold, with the city receiving approximately $15 per 1,000 fbm. It is estimated that a timber cut of 1,000,000 fbm can be realized annually for the next 15 years. When the younger forests now existing on the watershed reach maturity in approximately 35 years, an annual timber crop of between 5,000,000 and 6,000,000 fbm can be harvested. Bremerton feels that this is good business, for, in addition to having a well managed forest giving protection to its water supply, the revenue derived from the program will be a substantial factor in the financing of the water system and will aid in its future expansion.

Seattle

In its virgin state, the Cedar River watershed was covered with a dense and continuous old-growth forest. Timber cutting and attendant logging operations were already in progress in 1901, when Seattle first started to use the Cedar River supply, and have continued ever since. Cutting operations have reduced the stand of virgin timber to its present area of 37,260 acres, supporting an estimated 1.8 billion board-feet (9 per cent owned by Seattle, 46 per cent national forest, and 45 per cent privately owned). In the meantime reforestation of the cut-over areas has been accomplished, and, except for the lands recently logged, the watershed is still covered by a forest, but one in which many tree age groups are represented.

In 1924, following several disastrous fires that swept portions of the watershed, a complete forestry survey of the watershed was made and recommendations were submitted with regard to

the removal of the existing forest and the reproduction of a new one. Thereafter the city established a definite program of forest management, supervised by a forester permanently employed as part of the staff of the water department. The watershed is large enough for economical management and operation as an independent forest unit. The water department has a group of employees engaged in fire protection and reforestation work, timber management, and related activities.

Protection from fire has been an important part of the management program. In addition to the well trained, permanent watershed force, several fire guards and lookouts are employed during the summer. Two fire lookout stations and a headquarters camp are maintained. An adequate supply of fire-fighting tools and equipment—including portable pumps, hose, tank trucks, fire trucks, and an assortment of hand tools—is provided. An extensive system of roads and truck trails, covering much of the watershed,

Fig. 7. Cedar River (Seattle)

Properly regulated, this swift-flowing river provides a sustained withdrawal of 300 mgd.

has been constructed as part of the fire protection program. These roads also aid in the sanitary patrol of the watershed and can be used in the transportation of logs and timber products. The watershed telephone system is supplemented by short-wave radio.

Fire-swept logged areas have been reforested by planting, using trees grown in the water department nursery, located at Walsh Lake in the watershed. Since 1924, 6,050 acres have been planted, using more than 5,000,000 seedlings, nearly all Douglas fir. With this area excepted, all logged areas have been, or are being, reforested by natural means.

All logging is now being done under the 1945 Cedar River logging agreement, a contract between Seattle and the three private timber owners represented on the watershed, providing for the orderly harvesting of the remaining stand of old-growth timber over a 40-year period. Under this contract, all logging is being carried on by one operator, which has greatly simplified the problems of sanitation, fire protection, and watershed management for the city.

Sales of city timber can be made only with the approval of the city council, while the US Forest Service has its own timber sale contract. The method of cutting is in accord with the best forestry practices. The yearly cut of timber is limited to 35,000,000 fbm, the maximum sustained annual yield of the watershed. Provision is made for sanitary and fire regulations set up by the city. The city is paid for the use of its roads to transport logs. Road revenues for the past 8 years have amounted to $112,335. Provision is also made for the transfer of the remaining privately owned lands to the city without cost after they have been logged. The agreement also gave the city timber company land, at no charge, for use in the land exchange program under which Seattle is acquiring the national forest lands within the watershed.

Clear-cutting timber in strips or staggered areas is practiced, with high-lead logging the principal method employed. Relogging, or the removing of small-size material following the main logging operation, greatly reduces the volume of logging slash remaining. This slash, usually left unburned, provides a protective blanket over the soil and helps speed up reforestation. During the 8 years of operation of the Cedar River logging agreement, the area cut over has averaged 414 acres per year.

As logging progresses, sales of city timber are made. Such sales are for limited areas and run for a period of 12–18 months. The revenues from past timber sales have been nearly sufficient to repay the city's entire expenses for watershed acquisition. Future sale of the 2,500 acres of old-growth timber still owned by the city will produce accumulated revenues far exceeding the cost of watershed capital to the city.

In recent years second-growth stands of alder have been sold. Areas cleared of alder are being reforested by planting coniferous trees, in order to eliminate the objectionable alder as nearly as possible from the watershed area. Salvage sales of windfalls and snags have also been made, the city receiving revenue from this material, which otherwise would be wasted.

Throughout the past 50 years, both the water and the timber resources of the watershed have been developed.

Seattle feels that this is a wise management policy, for, just as the watershed produces a continuous supply of water, so it can also produce a continuous crop of timber, which, on being harvested, enters into the economy of the community, providing employment for many citizens; raw materials for the sawmill, plywood, and pulp and paper industries of the region; and a substantial source of revenue for the city.

Tacoma

Because of fires at various times in the past and logging operations dating back to the 1880's, the stands of timber in Tacoma's Green River watershed vary in age from young second growth to overmature virgin forests. The forest bordering the Green River and its major tributaries is composed principally of alder and cottonwood. Douglas fir and hemlock on the lower slopes and ridges give way to silver fir, alpine fir, and mountain hemlock on the higher ridges. The average growing time required to produce commercial timber in the watershed is about 100 years.

The small percentage of land in the bottoms owned by Tacoma was logged 40–50 years ago and is now covered with a forest of cottonwood and alder. It is part of a long-range plan to harvest this hardwood timber and then reforest the areas with conifers, such as Douglas fir, hemlock, and spruce. Large landowners are following similar programs of reforestation, and the city is constantly encouraging the logging of small areas in the mature forests, saving the younger or immature timber for future use. All logging procedures are outlined in a manual of watershed rules and regulations, published by the Tacoma Water Div.

One of the major problems involved in logging is the disturbance of the topsoil, with consequent erosion and possible changes in runoff characteristics. Since 1950 the city has been making an extensive sediment and turbidity investigation, in cooperation with the US Geological Survey. It is hoped by this means to learn what corrective measures will be needed to protect the quality of the water supply. Seven gaging stations have been established to secure information on what changes in runoff characteristics, if any, can be attributed to the removal of cover vegetation. This is a long-term study and there will be no evaluation of the data collected until the elapse of a sufficient length of time to arrive at reliable conclusions. The cutting operations of timber owners have been adjusted to aid in carrying on this work.

Vancouver

Of the three watersheds owned by and under the control of the Greater Vancouver Water Dist., one has been partly cut over, while the other two are virtually in their original state. A considerable area of the Capilano Valley was logged between 1918 and 1932. The district, after its acquisition of the Capilano catchment area from the city of Vancouver in 1926, negotiated with the company owning timber-cutting rights in the area and purchased its holdings outright. Since 1932, when the last timber was cut, it has been the policy of the district not to remove any timber from the catchment areas except for clearing reservoir sites and setting up firebreaks.

An appraisal of the forest resources of the watersheds, however, is currently being undertaken by a firm of

forest management engineers to determine the economic feasibility and appropriateness of a limited removal of mature timber. The areas previously cut over in the Capilano Valley are being satisfactorily reforested by natural processes, seed broadcasting, and hand planting.

Sanitary Protection and Policing—*Robert A. Duff*

A paper presented by Robert A. Duff, Supt., Water Commission, Medford, Ore.

Five of the six cities under discussion have organized police patrols to discourage and apprehend trespassers on their watersheds. These five all obtain their supply from surface streams and lakes. The sixth city, with a spring supply, has only a casual patrol. All the cities control or prevent habitation on the watershed lands. Where habitation is permitted, strict sanitary rules are enforced. Finally, all the cities rigidly test the waters for contamination.

Medford

The US Forest Service has been most cooperative in maintaining the sanitary standards of the watershed. The ranger patrols report any adverse conditions and nuisances. Strict sanitary regulations are enforced for logging operations on the watershed. The city pipeline patrolman and caretaker at the water supply intake, who travels over the area from one stream flow gaging station to another, reports any unusual conditions or occurrences that would be detrimental to the water supply. Because the Medford watershed is an underground catchment area, rigid control of the surface water supply does not have to be maintained. The integrity of the supply is evidenced by many years of perfect bacteriological records.

Portland

The federal law creating the Bull Run Reserve prohibits settlement or stock grazing in the area. Entry is forbidden to all except forest rangers, other persons employed by the federal government to protect the forest, and Portland Water Dept. personnel. State laws and city ordinances have also been enacted to control trespass in the area.

Bremerton

State and county roads afford easy access to all of Bremerton's four watersheds, the nearest of which is adjacent to the city limits, the center of the area being less than 10 miles from the city. A railroad and a paved highway both traverse about 3 miles of a densely wooded section of the watershed. Most of the city-owned property is fenced off, and all boundaries are well marked with signs warning against trespass. To guard against contamination and fire, city employees patrol the area daily, using a jeep to travel over the rough roads. The greatest trouble comes from irresponsible persons who dump garbage from cars while driving through the watershed. Several of the employees are deputized by the sheriff and have made arrests. Publicity is helping to reduce such incidents. The city posts signs offering rewards for apprehending

these offenders, and county officials have enacted legislation to prohibit parking on the highway. Brush picking, a profitable business in this locality, is an inducement to trespass, as are the many attractive trails and lakes. The area is closed to hunting and fishing.

The game department assists in patrolling, and, during the fire season, the State Forestry Dept. maintains a constant watch for persons entering the area. The city is purchasing additional property when available and enters into agreements with timber companies and the State Forestry Dept. to fence and police areas that contribute to the water supply. A residence is furnished the chief patrolman near the main reservoir, not far from the city limits.

All reservoirs are checked daily. Water is treated with ammonia and chlorine or chlorine alone.

Fig. 8. Cedar Lake (Seattle)

This 2¼-sq mile lake on the Cedar River, above the Landsburg intake, has been developed to provide 57,000 acre-ft of storage.

Bremerton plans to develop an additional supply capable of meeting anticipated demands for the next 100 years. Water rights have been applied for and property is being acquired so that the city will have maximum control of the supply.

Seattle

Responsibility for the sanitary protection of Seattle's Cedar River watershed rests with the office of the sanitary engineer in the water department. The four sanitary patrolmen employed are furnished residences at strategic locations on the watershed boundaries. The watershed is divided into patrol districts, with a patrolman assigned to each, although the patrolmen may, and do, whenever conditions dictate, operate in any or all districts.

The duties of the patrolman are to detect and prevent trespass on the watershed and to check the various forms of use existing on these lands for conformity with sanitary regulations. Watershed uses, other than the basic one of water supply, include logging, power production, and rail transportation.

All permanent habitation within the watershed area is now concentrated in the community of Cedar Falls, which is actually situated over a low divide, with drainage away from the Cedar River. The portion of this community housing the Seattle light and water department employees is served by a modern sewer system, with sewage treatment in an Imhoff tank, the effluent from which is chlorinated before being wasted in the ground. The railroad and logging camp communities are serviced by septic tanks, with no chlorination. All work crews are transported to and from the job so that overnight habitation, except for such assignments as fire lookouts, is not necessary. Points where work is in progress are equipped with portable chemical toilets. Records of the working population within the watershed are kept.

The waters of the Cedar River and of many of the tributary streams are sampled weekly and tested for *Esch. coli* in the department laboratory in Seattle. On the average, twenty such samples are run each week. Test samples at the Landsburg intake are consistently below the standards set by the US Public Health Service for raw water. Regulations require the locking of all toilets on passenger trains while traveling through the watershed. Chloramination is provided at the control works below Lake Youngs. The average dosage is 0.078 ppm ammonia and 0.35 ppm chlorine. Supplementary treatment, using sodium hypochlorite, is administered at several of the reservoir outlets within the city.

Tacoma

The Tacoma Water Div. has always taken the stand that good forestry practice and good runoff characteristics go hand in hand. By policing the holdings of large landowners daily, the division protects its water supply. To obtain greater police authority than that granted by the rules and regulations of the State Health Dept. and the State Pollution Commission over lands not owned by the city, Tacoma has entered into agreements with the majority of the large landowners in the watershed. These agreements allow the city to eject any person found trespassing. In return, the city has initiated various studies to record timber growth and has also cooperated in

working out engineering problems in connection with road construction, bridge crossings, and drainage. This plan has been beneficial to the city, as well as to the landowning companies.

In watershed management, it is extremely important that persons selected to act as inspectors be cooperative and diplomatic, because their work is more in the nature of education and dissemination of correct information than of enforcement of strict sanitary regulations. The success of the management plan depends on the development of friendly cooperation. Close daily contact with the problem is absolutely essential to obtain maximum results and benefits.

Vancouver

Stringent regulations of the Provincial Board of Health require that all employees authorized to enter watershed areas must submit to health tests from time to time. Other persons are prohibited from entrance except under very special circumstances, and then only after taking a health examination. All access roads into watershed areas are closed by barriers under guard. The perimeters of the watershed lands in sections frequented

Fig. 9. Green River Headworks (Tacoma)

The Green River gravity system furnishes 95 per cent of Tacoma's water supply.

by mountaineers and skiers are patrolled. All employees engaged in protection work are sworn in as constables, so that provincial regulations can be vigorously enforced.

All open reservoirs in the metropolitan area are fenced to prevent trespass, and the adjacent areas are landscaped to prevent surface runoff from entering the storage reservoirs.

Public Entry for Recreation—*T. V. Berry*

A paper presented by T. V. Berry, Commissioner, Greater Vancouver Water Dist., Vancouver, B.C.

Medford

No attempt is made to control public entry into the Medford watershed for recreational purposes. Hunters and fishermen use the area without restriction, and no adverse effects have been observed. Evidently, any contamination that occurs is dissipated before reaching the underground supply.

The recently constructed Willow Creek Reservoir has a very attractive shoreline, and its waters are ideal for the growth of trout. The State Game Commission has requested permission to stock the lake and make a recreational area of the site. Tests and observations indicate that the reservoir waters do not contribute to the spring source of supply. When the reservoir is designated a recreational area by the city, provision will be made for adequate sanitary facilities. Public use will be restricted to supervised areas.

Portland

Public entry into Portland's watershed area is prohibited by law, although visitors are permitted if accompanied by an authorized employee. A former city commissioner of public utilities, as a political promotion device, occasionally conducted automobile caravans of his constituents to the storage dam and headworks. These all-day excursions, held on Saturday or Sunday, required the services of water department cars and employees, at a cost to the department of $150–$250 per trip. In addition to the expense, there was also the nuisance of trying to police the participants and cleaning up the grounds afterward. This practice was discontinued immediately after the expiration of the commissioner's term of office.

Bremerton

The Bremerton watershed is readily accessible to the public from the railroad and highways skirting and traversing the area. Fortunately, the city owns the greater portion, particularly the section containing lakes, ponds, and streams contributing to the supply. Adjoining areas are owned by individuals or timber companies that carry on tree-farming projects and frown on trespassers. Constant patrolling by the city is necessary, but at present municipal police powers do not extend beyond the city boundaries.

Public entrance to city property is permitted only for specific purposes. Each year since 1946 school children, under the supervision of trained foresters and city employees, have been allowed to plant 1,500–2,000 trees. Other organized groups are given the same privilege. Boy scouts with re-

sponsible leadership may hike through the watershed, but camping is forbidden. The Army has been permitted to hold training maneuvers in the rugged areas, with the officers in charge responsible to the city. Picnicking is permitted in a park maintained by the city below the intakes. Tables and a playground are available. For educational purposes, organized groups are guided over the watershed by city employees, who explain the need for protecting supply sources.

Hunters have been permitted to use a road to cross a section of the watershed in order to reach a popular deer-hunting area. During the 2-week hunting season the gates are opened in the morning, hunters are checked in and out with the aid of game officials, and the gates are locked again in the evening. This is not a desirable situation, but, until the city can obtain control of the hunting area, it believes that by cooperating with the sportsmen it will gain their respect for the regulations.

Seattle

The general public is excluded from the Cedar River watershed, and recreational use in any form is prohibited. The enforcement of this regulation is part of the duties of the four sanitation patrolmen. Much of the western boundary of the watershed, particularly the accessible areas, has been fenced, thus definitely indicating the location of the boundary and aiding in the exclusion of would-be trespassers.

Individuals or groups, both local and otherwise, often ask permission to visit the water supply area and observe the many phases of watershed management and operation at first hand. Such requests, showing an interest in securing knowledge and information, are welcomed, and trips conducted by supervisory personnel of the water department are arranged. These trips have proved beneficial both to the department and to the visitors.

Tacoma

The Green River watershed at one time was accessible from the east through Stampede Pass and from the south through Twin Camps, but the original roads have been obliterated by rock slides and erosion. The Twin Camps road was destroyed beyond repair. Part of the Stampede Pass road was relocated by the Bonneville Power Administration and is now used as a patrol road. At present it is the only road available for public access. It is subject to slides and heavy snows and cannot be maintained during the winter. Although there are other patrol roads, one to the south over Grass Mountain and a second to the west along the North Fork of the Green River, locked gates close both of these to public travel. The only other means of transportation is the Northern Pacific Railroad, which traverses the length of the watershed from the headworks to Stampede Pass. For most of the distance, the railroad is so close to the river that all or part of it is within the original 400-ft wide land grant right of way. This proximity at times complicates the disposal of game that has been killed by trains.

Public recreational facilities in the Green River watershed are nonexistent. The only area that had any recreational value in the past—Hot Springs, near Lester—has since been purchased by the city. The one tourist hotel, which was built on the Hot

Springs property, burnt down about the time the Green River gravity line was being completed. The watershed population, which is directly dependent on the timber and railroad operations for its livelihood, varies from approximately 250 in the winter to 600 when weather conditions permit logging.

Vancouver

The Greater Vancouver Water Dist. does not permit any public entry into its watershed areas for recreational purposes. In district-owned buffer zones below the intakes contiguous to the catchment areas, licensed fishermen are, however, permitted. This arrangement has proved satisfactory over the years.

Open reservoirs in the metropolitan area are located near recreation sites, but fences effectively keep the public at a safe distance. The roof of one closed reservoir is used for bowling and tennis. The roof of a new covered reservoir being planned for Queen Elizabeth Park in the center of the city of Vancouver will be used for similar recreational purposes, under the administration of the Vancouver Parks Board.

Algae and Weed Control—*C. C. Casad*

A paper presented by C. C. Casad, Supt., Water Dept., Bremerton, Wash.

The natural environment of the mountains and forest cover on the watersheds tends to influence control of the algae and weed growth in water supplies of the Pacific Northwest. In general, the supplies developed on watersheds extending into the Cascade and Coast ranges, paralleling the Pacific Coast, are typical of the Pacific Northwest. The mountains are steep and rocky, with deep canyons and valleys expediting runoff to streams, while steep gradients give a high-velocity flow. The character of the watershed floor does not permit ground storage, and the wide difference between maximum and minimum flows makes it imperative that adequate storage be provided to meet the seasonal demands for water. The combination of forest-covered watersheds and cool water running swiftly through deep channels naturally retards algae and weed growth. All the cities under discussion, except Bremerton, depend on water supplies that originate in the rugged Cascade and Coast ranges. Bremerton derives its supply from watersheds with similar characteristics.

The growth of green algae depends upon the weather and usually occurs in the period from late April to October. The algae first appear in the small feeder streams entering the reservoirs and in the shallow water along the shores of lakes and open reservoirs. As the sun causes the temperature of the upper strata of water to rise, the algae growths are stimulated. They are found at depths ranging from 4 to 10 ft below the surface.

Patrolmen make frequent inspections of areas where experience has indicated the occurrence of algae, and prompt treatment results in satisfactory control. Throughout the season of algae growth, tests are made by sanitary engineers to determine the

need for and extent of treatment. The algicides used include copper sulfate (the most common), chlorine, ammonia, and calcium and sodium hypochlorite.

Medford

Medford has lined reservoirs, eliminating the weed problem. Algae troubles are confined to two open reservoirs in the city. The water supply, derived from a series of springs located near the summit of the Cascade Range, is collected in concrete galleries and piped to the city. The water is not exposed to sunlight until it is stored in the two open reservoirs.

The reservoirs are treated weekly with copper sulfate, and are brushed down with a stiff-fiber broom. The copper sulfate is applied by dragging a screen arrangement containing the chemical up and down the sloping sidewalls. This treatment has proved satisfactory in keeping the algae under control.

Fig. 10. McMillin Reservoir (Tacoma)

The twin concrete-lined reservoirs each hold 52 mil gal. (The peak faintly visible in the background is Mount Rainier.)

Portland

Algae and weeds are not a serious problem in Portland's Bull Run water

supply. The relatively low temperature of the water and the absence of direct sunlight on the streams flowing through deep forests tend to retard growths. Green algae in Lake Ben Morrow are confined to a few spots where the water is shallow and where the sun has a chance to warm the upper strata of the water. A few small feeder streams emptying into the lake are treated to keep them growth free.

The green algae are controlled by the use of copper sulfate. Within 2 hr after application there is a noticeable fading in the color of the algae, and within 24 hr the color is entirely gone, leaving only a grayish-white film that decomposes and disappears. Spot treating about once a month is sufficient.

There is little shallow water to encourage weeds. Sedges and tule grass are found in occasional patches, but generally the banks are free from such growth.

Bremerton

Four watersheds contribute to the Bremerton surface water supply. Storage in three lakes and three unlined reservoirs is provided on the watershed. All water sources are patrolled regularly, and the first growth of algae is treated promptly with copper sulfate, cast by hand into shallow water and dragged in a sack through deep water. Applications are made as required, and the residual of copper is held to 0.3 ppm.

An 11-mil gal concrete-lined reservoir receives water directly from the source of supply. The reservoir is 50 ft deep, with steeply sloping walls. Treatment consists of copper sulfate and chlorine-ammonia. The water level is lowered to expose the affected area, which is then sprayed with a strong solution made from granular copper sulfate. Ammonia and chlorine are introduced into the supply main about half a mile from the reservoir. A chlorine residual of 0.4–0.5 ppm is maintained at the point of application, resulting in a residual of 0.1–0.2 ppm in the reservoir.

Two concrete settling tanks are cleaned weekly with stiff-fiber brooms. Any algae on the vertical walls are sprayed with copper sulfate.

Weeds give little trouble. Two lakes with reeds and lily beds are used to impound water that, except when the lakes are employed for flood control, eventually reaches the pumping station below by infiltration into the ground supply.

Seattle

Seattle has an algae problem in the Cedar River watershed and the Lake Youngs reservoir. Control on the watershed has been limited to the Cedar River and its tributaries below Cedar Lake.

Algae growth is combated with copper sulfate, cast into the streams by the sanitation patrolmen. The time, place, and volume of application are determined by the patrolmen through visual observation. Weekly checks are made by the sanitary engineer.

Lake Youngs covers approximately 750 acres. The main body of the lake is treated in the spring by means of an inboard motorboat, on the stern of which is fastened a large metal box with a ¼-in. screen. Lumps of copper sulfate crystals are shoveled into the box from a stockpile as the boat is driven swiftly through the water in a checkerboard pattern. To treat the shoreline, a piece of equipment de-

veloped by a water works employee is used. An air compressor mounted on a truck forces air into a venturi tube at the lower end of a hopper filled with copper sulfate granules. As the truck is driven along the shore, the crystals are discharged into the water by air pressure. The speed of the truck, which varies from 10 to 20 mph, regulates the dosage. The operation requires two men, one to drive the truck and the other to keep the hopper filled. This treatment has been found both effective and economical. About 7½ tons of copper sulfate is required to treat Lake Youngs.

Algae also occur in the concrete-lined open reservoirs within the city. The growths attach themselves to the walls from the water surface to a depth of 3–5 ft. Two or three times a summer sodium hypochlorite tablets, at 15 per cent strength, are cast on the sloping walls near the surface of the water, where they dissolve, destroying the algae and supplying additional chlorine to the water. This method is very satisfactory, but care must be

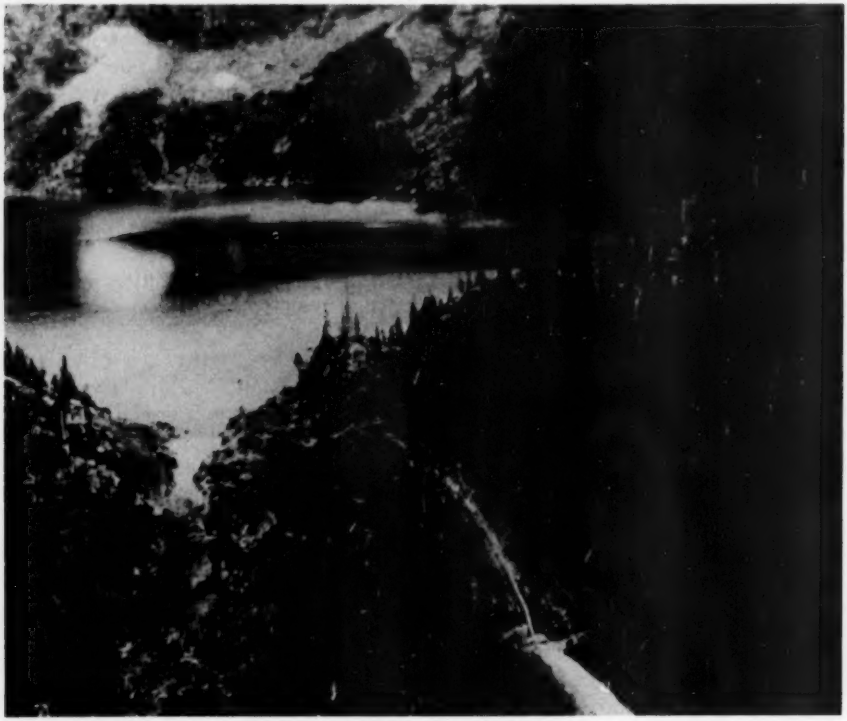


Fig. 11. Palisade Lake (Vancouver)

Water from this 126-acre lake is drawn off through a tunnel 145 ft below the surface.

taken to prevent taste and odor in the water.

Weed control has been a serious problem on the Seattle watershed. Burning and copper sulfate concentration along the shoreline of the lake have given good results. Some difficulty is experienced with an underwater plant of the fern family. The plant grows 3–4 ft below the surface and has been difficult to eliminate. A method under consideration is to lower the lake level and kill the growth by exposing it for several weeks or more. As the plant produces spores that may survive from one year to the next, it may take several years to eliminate it entirely.

Tacoma

Tacoma receives its gravity supply from the Green River, which has its source in the Cascades. Because the headworks dam on the river is situated in a narrow canyon through which the Northern Pacific Railroad runs, there is little storage volume at the intake. The narrowness of the canyon, to-

Fig. 12. Seymour Falls Dam (Vancouver)

This dam, on the Seymour River, creates a 1,080-acre-ft balancing reservoir.

gether with the steep gradient of the river, creates sufficient water velocities at all seasons of the year to prevent growths along the river channel almost entirely. The diversion dam pool is protected from the rays of the sun during most of the year, a condition that is not conducive to algae growth. No treatment is provided at the pool.

A slime bacteria growth in the 27-mile supply pipeline between the intake and McMillin Reservoir is controlled by prechlorinating the gravity supply as it leaves the intake. The daily average initial chlorine demand varies from 0.25 to 2.0 ppm, the maximum occurring during heavy floods. The 20-min chlorine residual is approximately 0.25 ppm in winter and 0.40 ppm in summer. The residual is usually maintained at 0.10 ppm.

The McMillin Reservoir installation consists of two concrete-lined 52-mil gal reservoirs. They are 20 ft deep, and algae may be found to a depth of approximately 10 ft. Both chlorine and copper sulfate are used to control growths. When additional chlorine is needed, it is administered by the chlorinators at the intake diversion dam. The chlorine travels down the gravity line and disperses throughout the water in the reservoir, raising the overall residual and destroying the algae. The most effective way of treating the reservoir with copper sulfate is along the sloping sides. By this method, the concentration along the edges may be raised as high as 10 ppm, which decreases to less than 0.1 ppm after dilution. The water is again chlorinated as it passes from the reservoir to the main line, in order to maintain a distribution system residual of 0.1–0.2 ppm.

Vancouver

The Greater Vancouver Water Dist. operates both lined and unlined storage reservoirs. To date the district has been fortunate in not having difficulty with algal or weed growths in its reservoirs.

Characteristics and Effects of Synthetic Detergents

Task Group Report

A report of Task Group E5.15—Effects of Synthetic Detergents on Water Supplies, presented on May 25, 1954, at the Annual Conference, Seattle, Wash., by Paul D. Haney (Chairman), Engr., Black & Veatch, Kansas City, Mo. Other members of the task group were: R. L. Culp, J. D. Enright, W. D. Hatfield, H. E. Lordley, and J. C. Vaughn.

Introduction

AN AWWA task group to consider the effects of synthetic detergents on water supplies was formed in September 1953 by action of the Executive Committee of the Water Purification Division. This preliminary report brings together what the task group believes to be important background information on the use and nature of synthetic detergents. In addition, brief consideration has been given to analytical methods for detergents and to their behavior in sewage and surface water. One section of the report reviews actual water plant operating experiences. Other sections deal with water treatment methods and with suggestions for future lines of investigation.

Definitions

Detergent. According to the dictionary, as quoted in Niven (*1*), the term "deterge" means "to cleanse" or "to purge away." The term "detergence" or "detergency" denotes "cleansing quality or power." When used as an adjective, the word "detergent" may be considered to mean "cleansing" or "purging," while the noun denotes "a cleansing agent." McCutcheon (*2*) defines a detergent as "any chemical material which has the property of cleansing." Larson (*3*) characterizes a good detergent as a material that: [1] is soluble in water; [2] permits the water solution to penetrate capillaries by lowering the interfacial tension (*wetting* action); [3] breaks up or separates particles that have agglomerated (*dispersing* action); and [4] links the dirt or oil particles with the water (*emulsifying* action) rather than with each other or with the substance being cleaned.

Soap. Soap, which is a sodium or potassium salt of a long-chain organic (fatty) acid, is a detergent. It may be formed by the alkali saponification of animal or vegetable fats, the latter being the glycerides of long-chain organic acids. Soap is not stable toward acids and heavy metals. Acids and the hardness-producing constituents of water (calcium and magnesium) react with soap and destroy its detergent qualities. These defects in the properties of soap stimulated the development of synthetic detergents.

Surface-active agents (surfactants). Surface-active agents are important constituents of synthetic detergents and may be defined as solutes which possess the property of altering the surface or interfacial properties of their solutions to an unusual extent, even when they are present in low concentrations (*4*). Many soluble substances exhibit surface-active properties, but all surface-active agents do not possess a satisfactory balance of detergent properties. From the standpoint of detergency, the term "surface-active agent" implies an organic compound that combines the important detergent properties of wetting, dispersing, and emulsifying with, at least, the quality of hardness stability. These characteristics will, of course, vary with the chemical nature of the manufactured surface-active agents.

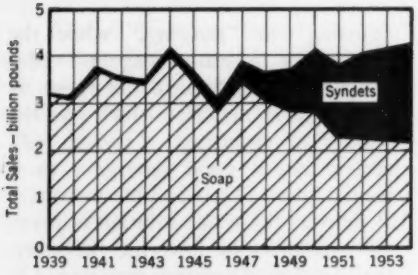


Fig. 1. Soap and Syndet Sales

The remarkably rapid increase in the syndets' share of the detergent market is evident (7).

Surface-active agents may be classified, according to their ionization in water, as anionic, cationic, or nonionic. The anionics are by far the most important commercially and are, therefore, the ones most likely to be found in streams and lakes receiving waterborne wastes from cities and industries. The use of nonionics, however, is on the increase.

Synthetic detergents. The term "synthetic detergent," as commonly used, is not susceptible to rigorous definition. Products ordinarily called "synthetic detergents" can be—and are, in many instances—classified as "surface-active agents" or "detergent surfactants." Furthermore, many products designated "synthetic detergents" contain, in addition to surface-active agents, various other organic and inorganic compounds that are intended to improve detergent action or other properties. These supplementary com-

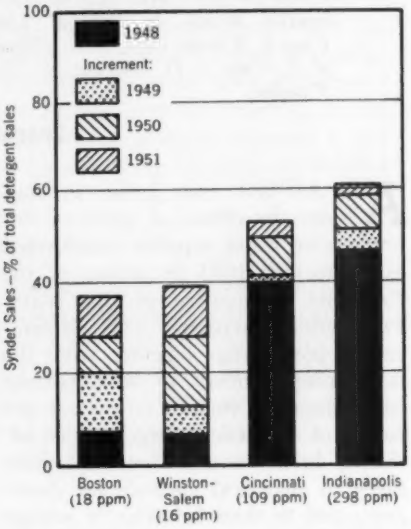


Fig. 2. Water Hardness and Household Syndet Sales

The values in parts per million represent average water hardness. The sales data are for household packaged and liquid detergents (7).

pounds, generally termed "builders" (*2*), include polyphosphates, sodium silicate, and sodium carboxymethyl cellulose (a dirt-suspending agent). Products employing such aids may be termed "built detergents" (*2*).

According to McCutcheon (*5*), brands now on the market may be divided into two classes: [1] light-duty products for dishwashing and laundering (containing a neutral salt builder, chiefly sodium sulfate, and consisting of perhaps 30–35 per cent surfactant plus 60–65 per cent builder); and [2] heavy-duty products (containing builders such as tetrasodium pyrophosphate, polyphosphate, sodium carbonate, sodium metasilicate, and sodium carboxymethyl cellulose). Table 1 gives two examples of detergent formulations (*5*).

TABLE 1

Examples of Detergent Formulations

Component	Quantity *per cent*
Heavy-Duty (Industrial)	
Surfactant	
Alkyl aryl sulfonate	20
Builders	
Sodium tripolyphosphate	40
Sodium metasilicate	10
Sodium sulfate	28
Carboxymethyl cellulose	2
Packaged Household Detergent	
Surfactant	
Alkyl aryl sulfonate	30
Builders	
Tripolyphosphate	28
Sodium silicate	6
Sodium carboxymethyl cellulose	1
Sodium sulfate, sodium chloride, and moisture	35

Common usage of the term "synthetic detergent" to designate the surface-active agents employed in the preparation of "built detergents," as well as the "built detergents" themselves, has led to confusion. *As used in this discussion, the term "surface-active agent (or "surfactant") is reserved for those surface-active organic compounds which exhibit detergent properties plus stability toward hardness.* (Soap is a surfactant but is excluded because of its lack of stability toward hardness.) Dodecyl benzene sodium sulfonate is an example of such a compound. This surfactant is also acid and alkali stable (*6*).

Products containing "surface-active agents" plus "builders" are, for the purpose of this discussion, termed "synthetic detergents" (or "syndets"). The proportion and type of builder compounds will be dependent on the use to be made of the product.

Use of Syndets

The rapid increase in synthetic-detergent sales in relation to soap is shown in Table 2 and Fig. 1. Figure 2 illustrates the effect of water hardness on the percentage of the market captured by synthetic detergents. It is evident that water hardness was an important influence on initial sales, but there has been a definite gain even in the soft-water areas in recent years.

There are nearly 1,000 commercially available surfactants, but only a few are sold in significant volume. The 1952 production (*8*), in million pounds of surfactant, was approximately as follows: alkyl aryl sulfonates, 400; alkyl sulfates, 113; and nonionics, 90–100. The present capacity of plants in the United States is estimated (*8*) at

TABLE 2

*Packaged-Detergent Sales**

Year	Detergent Sales—*1,000,000 lb*			Per Cent of Total	
	Soap	Syndets	Total	Soap	Syndets
1948	1,568	384	1,952	80.1	19.9
1949	1,457	667	2,124	68.4	31.6
1950	1,349	1,016	2,365	57.0	43.0
1951	1,016	1,155	2,171	46.8	53.2

* Data quoted in Reference 7.

between 800 and 900 million pounds annually, divided approximately thus: alkyl aryl sulfonates, 43 per cent; alkyl sulfates, 12 per cent; nonionics, 12 per cent; and miscellaneous sulfates and sulfonates, 33 per cent.

Neidig and Hersberger (*7*) have summarized the outlook for the synthetic-detergent industry as follows:

To predict the future developments in an industry which is changing as rapidly as is the synthetic-detergents field requires clairvoyant powers. Nonetheless, certain trends seem to be developing which warrant mention:

1. While there will continue to be growth in the *packaged* field where synthetics now have about 53 per cent of the total of roughly 2.2 billion pounds, the upper limit which most industry people anticipate is 70–75 per cent of the total.

2. Whereas many of the packaged products now contain [as much as] 40 per cent active detergent, some of the newly marketed products contain 18–20 per cent of active and several per cent of additives having synergistic properties. This trend could create new opportunities for some of the more specialized surface-active agents, although it is expected the alkyl aryl sulfonates and alcohol sulfates will continue to be the "work horses" of the industry.

3. Real expansion in liquid detergents is anticipated to the extent that they may ultimately have at least 10 per cent of the packaged market.

4. New industrial applications will increase the demand for many of the surface-active agents.

Chemical and Physical Behavior

As previously stated, surface-active agents may be classified, on the basis of their ionization in water, as anionic, cationic, or nonionic (Fig. 3). In the anionics, the significant ion is an "anion," that is, one bearing a negative charge. In the cationics, it is a "cation," or one bearing a positive charge. The nonionics do not ionize appreciably in water.

Anionics

As the anionic surfactants are the compounds most widely used in the manufacture of synthetic detergents, they are of the greatest importance insofar as water pollution is concerned.

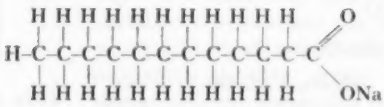
Alkyl aryl sulfonates. The alkyl aryl compounds are anionic surfactants. One type can be represented by the general formula:

$$R\text{–}C_6H_4\text{–}SO_3Na$$

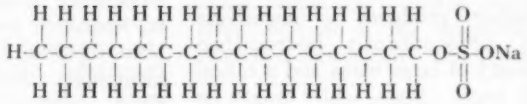
in which R represents the alkyl group, and C_6H_4 is the aryl or benzene ring group. The former is a straight or branched-chain hydrocarbon. Dodecyl benzene sodium sulfonate is a good ex-

Anionic

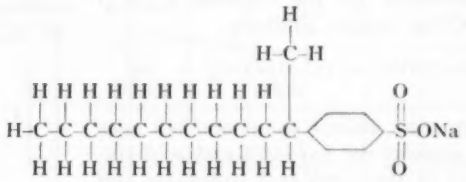
Soap



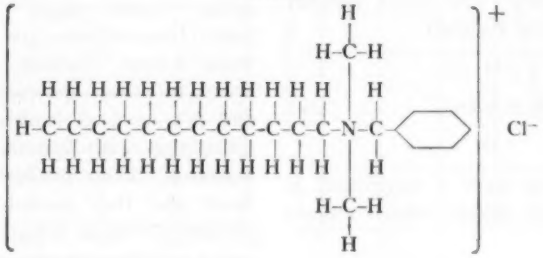
Alkyl Sulfate



Alkyl Aryl Sulfonate



Cationic



Nonionic

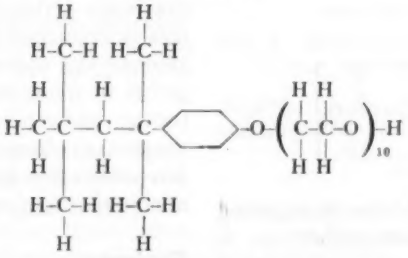


Fig. 3. Surfactant Structural Formula

ample of an alkyl aryl surfactant. Its formula is:

$$C_{12}H_{25}\text{–}C_6H_4\text{–}SO_3Na$$

or:

These compounds might be regarded as substituted sodium sulfate, one small part of the sodium sulfate molecule (NaO) being replaced by the complex hydrocarbon grouping.

Dodecyl benzene sodium sulfonate ionizes thus:

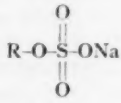
$$C_{12}H_{25}\text{–}C_6H_4\text{–}SO_3Na \rightarrow \underset{\text{anion}}{[C_{12}H_{25}\text{–}C_6H_4\text{–}SO_3]^-} + \underset{\text{cation}}{Na^+}$$

Ionization produces a negatively charged, predominantly hydrocarbon ion (anion) of large mass and a cation of small mass. Soap, which might be represented by the formula $C_{15}H_{31}$-COONa, ionizes similarly:

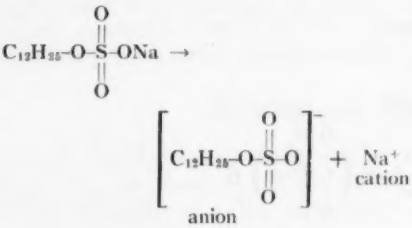
$$C_{15}H_{31}COONa \rightarrow \underset{\text{anion}}{[C_{15}H_{31}COO]^-} + \underset{\text{cation}}{Na^+}$$

Soap is an anionic compound but does not possess the hardness and acid stability of the alkyl aryl sulfonates and other similar surfactants.

Alkyl sulfates: The alkyl sulfates have the general formula:



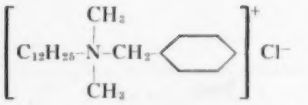
An example of such a compound is sodium dodecyl sulfate, which ionizes thus:



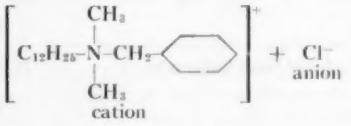
This compound might also be regarded as a substituted sodium sulfate.

Cationics

Examples of cationics are the quaternary ammonium compounds. A typical cationic structure is:



This compound might be regarded as substituted ammonium chloride; that is, hydrogen atoms of the NH_4 have been replaced by various hydrocarbon groupings. Ionization yields a positively charged, predominantly hydrocarbon ion (cation) of large mass and an anion of small mass:



These compounds are sometimes called "invert soaps" because their ionic characteristics are the reverse of those of soap. Cationic surfactants are noted for their germicidal properties and are used as sanitizing agents in connection with laundering and dishwashing. Their production volume is small and they probably present no problems from a sewage treatment or water pollution standpoint, for they are neutralized by the anionics that are practically certain to be present in excess in municipal sewage. Apparently anionics and cationics cannot exist together in water in appreciable concentrations and retain their identity. The results of interaction yield insoluble compounds that have neither detergent nor germicidal properties (*9, 10*).

Nonionics

As previously indicated, nonionic surfactants do not ionize in water. They are made by condensing certain fatty or oily material with several

molecules of ethylene oxide (*9*). An example of a nonionic ester is:

$$C_{17}H_{33}COOC_2H_4(OC_2H_4)_x\text{–}OH$$

The following is a nonionic ether:

$$C_8H_{17}\text{–}C_6H_4\text{–}OC_2H_4(OC_2H_4)_x\text{–}OH$$

These compounds are probably constituents of the recently advertised "controlled-suds" detergents. They

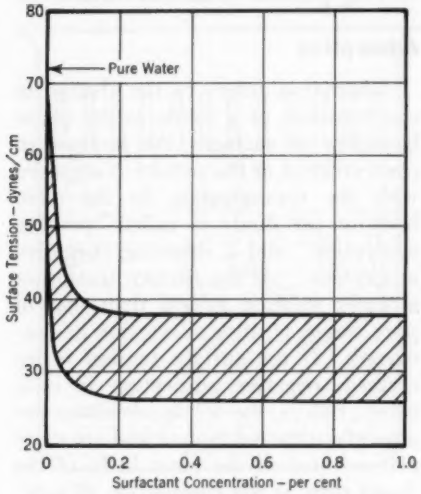


Fig. 4. Reduction of Surface Tension

As the surfactant concentration increases, the surface tension of water is lowered. Values in the shaded area apply to the majority of surfactants (11).

are said to have little tendency to foam (as compared with the anionics and cationics) and have good hardness stability (*6*). The nonionics may foam copiously, however, when mixed with other materials (*6*).

Surface Tension

At a water-air boundary, the attraction between the water molecules results in a force that tends to pull the surface molecules into the body of the water and to adjust the surface to the minimum possible area. Owing to this imbalance of cohesive forces at the phase boundary, a water surface exhibits certain of the properties of a stretched membrane. The force acting

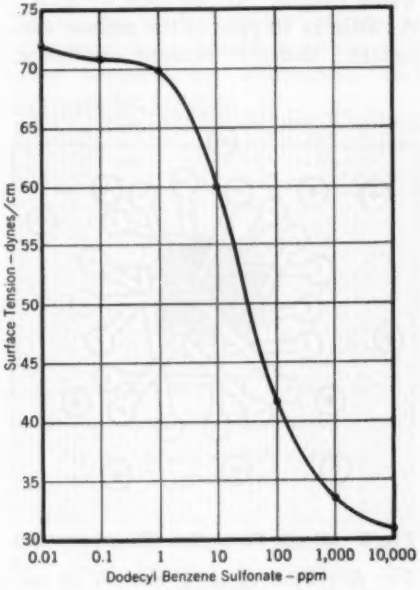


Fig. 5. Effect of Anionic Surfactant on Surface Tension

As little as 10 ppm of this surfactant reduces surface tension (at 25°C) about 20 per cent (12).

in the surface of a liquid and tending to restrict the surface area is termed "surface tension" and is measured in dynes per centimeter, that is, force per unit of length. The term "interfacial tension" includes surface tension but, by common usage, refers to the region of contact between immiscible liquids

or between a solid and a liquid, whereas surface tension generally refers to the area of contact between a gas and a liquid—such as air and water. The surface tension of water decreases with increasing temperature.

Surface-active agents in concentrations of 0.1 per cent (1,000 ppm) or more reduce the surface tension of water roughly 50 per cent (Fig. 4). As little as 10 ppm of the anionic surfactant, dodecyl benzene sulfonate,

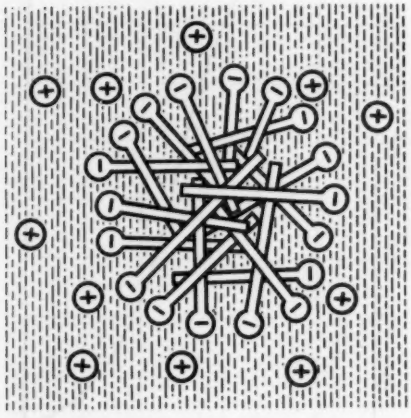


Fig. 6. Micelle Formation (Diagrammatic)

The formation of these clusters of surfactant ions (14) is regarded as an important aspect of detergent action.

produces a reduction of about 20 per cent (Fig. 5).

Bowers (*13*) has presented two interesting and valuable papers on the surface tension of sewage.

Lowering of the surface tension is one of the factors associated with sudsing or foaming. The latter is a complicated phenomenon and many other factors probably influence foam formation tendencies and foam stability.

The natural production of surface-active agents in vegetation, both in the living state and during decomposition, is considerable. The existence of these natural surfactants can be demonstrated by soaking grass, straw, or leaves in water. The extracts foam, and there is substantial lowering of the surface tension of the water. Raw waters may be expected to contain varying amounts of natural surfactants.

Adsorption

Adsorption refers to the change in concentration of a solute at the phase boundary or surface. An increase in concentration at the surface (compared with the concentration in the main body of the fluid) is called "positive adsorption" and a decrease "negative adsorption." If the surface tension of a water solution is less than that of pure water, positive adsorption has occurred. If the surface tension is increased, negative adsorption is indicated; that is, the solute molecules are strongly attracted inward and are more concentrated in the main body of the liquid than at the surface (*4, 10*).

Many inorganic salts are negatively adsorbed, and the surface tension of solutions of these substances is somewhat higher than that of pure water. On the other hand, most water-soluble organic substances exhibit positive adsorption, with consequent lowering of the surface tension of water. The surface-active agents show this effect to a marked extent. The magnitude of the lowering of the surface tension of water by small amounts of certain organic material, notably the surfactants, is far greater than the increase produced by similar quantities of inorganic substances.

Micelle Formation

The behavior of extremely dilute solutions of ionic surfactants is similar to that of a strong electrolyte. As the concentration increases, however, the properties of the system deviate considerably from expected behavior. This divergence is due to formation of "micelles" (clusters of ions), as illustrated in Fig. 6. The micelles carry a charge

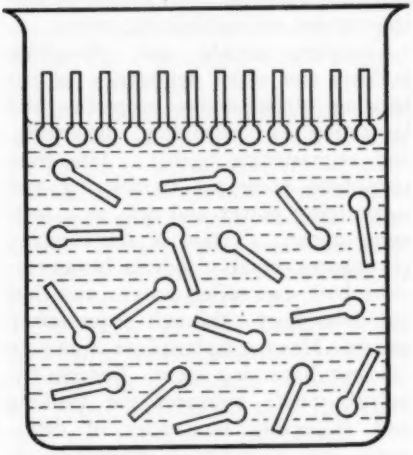


Fig. 7. Orientation of Surfactant Ions (Diagrammatic)

At the air-water boundary, the surfactant ions line up with the hydrophilic end toward the water and the hydrophobic away from the water (14).

and may therefore be termed "colloidal" ions. Micelle formation is regarded as an important aspect of detergent action (*1, 4*).

Mechanism of Detergent Action

Using an anionic surfactant as an example, detergent action may be partially explained as follows (*15*): The negative ion (anion) may be considered to consist of a water-repelling or hydrophobic group and a water-attracting or hydrophilic group. For the alkyl aryl compounds, this situation might be depicted thus:

$$[R\text{–}C_6H_4 \cdot \text{–}SO_3]^-$$

hydrophobic portion of ion · hydrophilic portion of ion

To exhibit marked surface activity, a compound must possess a proper balance between the hydrophilic and hydrophobic groups.

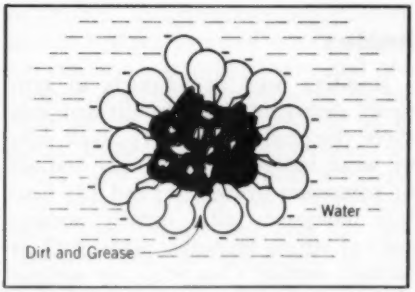


Fig. 8. Action on Dirt Particles (Diagrammatic)

Oriented surfactant ions surround dirt and grease particles, so that the latter have little tendency to coagulate and settle (15).

A previously discussed characteristic of surface-active agents is the lowering of surface and interfacial tension. Substances that lower surface and interfacial tension are attracted to the phase boundary. At the boundary, an anion containing a hydrophobic and hydrophilic group will orient itself with the hydrophobic portion away from the water and the hydrophilic portion toward the water. Orientation at the water surface is illustrated in Fig. 7. Similar action takes place at other

phase boundaries—for example, at a dirt-water interface. In the latter instance, the hydrophobic portion of the ion will be associated with any dirt or grease present, and the dirt or grease will be linked to the water through the hydrophilic group. This is shown diagrammatically in Fig. 8, where dirt and grease particles are completely surrounded by oriented ions from the surfactant. Dirt particles protected by an adsorbed layer of charged, oriented surfactant particles will have little tendency to coagulate and settle.

Builders

Builders used as adjuncts to synthetic detergents may be divided into three chemical classes: [1] alkali salts of weak inorganic acids; [2] sodium or potassium hydroxide; and [3] neutral inorganic salts—usually sodium salts of strong inorganic acids, such as sodium sulfate (Na_2SO_4) or sodium chloride (NaCl) (*1*). Commonly used alkali salts include:

1. Sodium carbonate (soda ash), Na_2CO_3
2. Modified soda—sodium carbonate plus sodium bicarbonate ($NaHCO_3$)
3. Sodium sesquicarbonate, $Na_2CO_3 \cdot NaHCO_3 \cdot 2H_2O$
4. Sodium tetraborate (borax), $Na_2B_4O_7 \cdot 10H_2O$
5. Sodium phosphate:

a. Trisodium phosphate—crystalline ($Na_3PO_4 \cdot 12H_2O$) or monohydrate ($Na_3PO_4 \cdot H_2O$)

b. Sodium tripolyphosphate, $Na_5P_3O_{10}$

c. Tetrasodium pyrophosphate, $Na_4P_2O_7$

d. Sodium hexametaphosphate, $Na_6P_6O_{18}$

6. Sodium silicate—Na_2SiO_3 up to $Na_2Si_4O_9$.

The surface activity of ionic surfactants is said to be affected appreciably by salts or other electrolytes in solution (*4*). Surface and interfacial tensions are lowered, probably because of the effects of ions derived from the salts on micelle formation (*4*). Sodium sulfate and sodium chloride in small concentrations improve the detergency of anionic surfactants through their effects on surface tension and solubilizing power.

Complex silicate and phosphate builders can assist detergency by enhancing surface-active properties and by acting as suspending, dispersing, and sequestering agents. Trisodium phosphate possesses emulsifying and saponifying power and acts as a softening agent. Certain of the complex phosphates, notably sodium hexametaphosphate, can soften water (and thus aid detergency) through sequestering action. Hexametaphosphate is also an efficient dispersing agent. Sodium tripolyphosphate increases the foaming and dispersing tendencies of detergents and, in addition, possesses sequestering power. Tetrasodium pyrophosphate is another phosphate builder that exhibits dispersing and sequestering properties. Tripolyphosphate is considered an essential major ingredient in heavy-duty detergents. Production of tripolyphosphate has increased from an estimated 100,000,000 lb in 1948 to approximately 800,000,000 in 1953.

It is important to remember that the major proportion (60–70 per cent or more) of many synthetic detergents consists of builder materials. Builders may have as great an influence on colloidal behavior in water as the surface-active agents themselves (*6*).

Analytical Methods

Anionic Surfactants

Methylene blue extraction method. Methylene blue dye is soluble in water but insoluble in chloroform. Sulfated and sulfonated anionic surfactants react with methylene blue to form a "salt" or complex that is soluble in chloroform. The intensity of the color produced by the soluble complex in chloroform can be measured photometrically and compared with a calibration curve produced with a selected anionic surfactant.

The conditions of extraction with chloroform must be adjusted so that the effects of possible interfering compounds, such as nitrites, nitrates, thiocyanates, and protein, will be minimized. A widely used methylene blue extraction method is that described by Degens and colleagues (*16*).

Two-phase titration method. The reaction of an anion-active agent with cation-active compounds permits a direct titration procedure to be combined with the extraction procedure. The method depends on the difference in solubility of dyestuff–cation-active agent complexes in water and in organic solvents (*17*).

When a solution containing a cation-active substance is added in small increments to a flask containing an aqueous solution of an anion-active substance, an organic solvent such as chloroform, and a small quantity of an acid dye, a sequence of reactions occurs. The cation-active agent first combines with the anion-active compound. When all of the latter has been used up, the cation-active substance combines with the acid dye to form a colored complex soluble in chloroform. The endpoint in the titration is reached at the first appearance of color in the chloroform layer. The solution of cation-active agent used in the titration is standardized against a known solution of a selected anion-active compound.

Edwards and Ginn (*18*) have studied this method. These investigators report a modification of the two-phase titration method which is rapid and accurate and is suited to use with sewage. Interference by soap and protein is eliminated by adjusting the pH to 7.0–7.5. Ethylenediaminetetraacetic acid is utilized to avoid errors caused by calcium and magnesium, and the method is said to be unaffected by sodium sulfate or sodium chloride up to about 1,000 ppm. Thiocyanates, nitrates, and nitrites do not interfere. The organic solvent used is hexane, and either bromphenol blue or azophloxine can be employed as the dyestuff.

Cationic Surfactants

Cationic surfactants are not now being manufactured and used in any great quantity. It is unlikely that significant amounts will appear in either sewage or water, because cationics are destroyed by reaction with anionics. Auerbach (*19*) describes an analytical method based on the fact that cationic surfactants of the quaternary ammonium salt type form colored complexes with certain dyes, such as bromphenol blue, which can be extracted from aqueous alkaline solutions by a number of water-immiscible organic solvents like ethylene dichloride or benzene. The intensity of the color is measured in a photometer and compared with a calibration curve pre-

pared using a known cationic compound.

Nonionic Surfactants

At present the use of nonionic surfactants in large amounts is not widespread, although it is increasing. Analytical work on these compounds has been exceedingly sparse, and the problem is further complicated by the bewildering array of types in this group. Three general methods of analysis have been applied. Shaffer and Critchfield (*20*) used phosphomolybdic acid to precipitate polyethylene glycols and then weighed the precipitate or digested the residue and determined the molybdenum. Heatley and Page (*21*) also used phosphomolybdic acid to precipitate polyglycols. The precipitate was dissolved in methyl cellosolve and the absorption determined with a spectrophotometer. Oliver and Preston (*22*) applied the phosphomolybdic precipitation method to the ethylene oxide type of nonionics.

Analytical Reference Standard

Lack of a suitable analytical reference standard for surfactants makes comparison of results from various laboratories difficult. This matter has been considered by the AWWA task group, and the advice of the detergent and chemical industry and others has been sought. Arrangements are now being made to secure a supply of an appropriate material for test purposes.

Toxicity to Humans

A limited review of the literature has revealed one, or possibly two, cases of fatal poisoning of a human resulting from the ingestion of a synthetic detergent. Adelson and Sunshine (*23*) reported the death of a 45-year-old woman who drank less than 1 oz (28.3 g) of an aqueous solution containing a 10 per cent concentration of the cationic surfactant, methyldodecylbenzyltrimethyl ammonium chloride. Mackenzie (*24*) noted either a similar case or the same one.

Fogelson and Shock (*25*) treated patients having gastroduodenal ulcerative disease with sodium alkyl sulfate, administering 0.2 g of this surfactant every 2 hr throughout the day. At least one patient was treated for more than a month. These authors reported no toxic effects in either man or experimental animals after 7 months' administration of this dose. Furthermore, Fogelson himself took 1 g of this surfactant daily for 8 weeks without any toxic effect.

Numerous investigators (*26–30*) have studied the relative toxicity of various commercial synthetic detergents and surfactants in mice, rats, rabbits, dogs, and monkeys. Hopper, Hulpieu, and Cole (*31*) and Woodard and Calvery (*32*) reported on both acute and subacute toxicity of various anionic, nonionic, and cationic surfactants.

About the only conclusions that may be drawn from toxicity data given in the literature are:

1. As a class, the cationics are the most toxic of the surfactants. (Fortunately cationics are neutralized by anionics, and the latter dominate the synthetic-detergent market.)

2. In general, the toxicities of the nonionics and anionics are of the same order.

3. The toxicities of the various surfactants within any given class, and

even of those of the same type, may vary greatly.

After having summarized the available information on the toxicity of surfactants, Woodard and Calvery (*32*) stated: "We are appalled by the many unanswered questions concerning the toxicological properties of surface-active agents. A major contributing factor to this paucity of information is undoubtedly the fact that the majority of the [commercial] surface-active agents are not reproducible chemical entities. They are in some cases impure, sometimes variable from batch to batch, and often mixtures of closely related analogs."

Although available information indicates that the problem of ingestion of synthetic detergents in drinking water is probably not too serious, additional study is considered necessary. The detergent subcommittee of the General Chemical Industry Committee, Ohio River Valley Water Sanitation Commission, has furnished the Kettering Labs., University of Cincinnati, with additional toxicity data on the alkyl aryl sulfonates. The Kettering Labs. are undertaking a thorough review and evaluation of possible toxicological hazards. Further information will be turned over to these laboratories as soon as the detergent subcommittee can collect it. (The AWWA task group on detergents has established liaison with this subcommittee and is exchanging information with it.)

A British committee on synthetic detergents has recently issued an interim report (*33, 34*). The committee has so far discovered no evidence of ill effects from the ingestion of traces of synthetic detergents. The committee finds no cause for alarm on the part of detergent users or public health authorities. The problem is classed as a nuisance, particularly for sewage works. Further careful study is recommended in relation to the efficiency of sewage treatment, the condition of rivers, and the purity of water supplies (*34*).

Effects on Surface Waters

The literature provides very little information on the effect and persistence of synthetic detergents in natural surface waters. Sawyer (*35*) states that the concentration of phosphorus—a key element in the fertilization of natural bodies of water— in synthetic detergents is 23 per cent by weight, and that the phosphorus content of domestic sewage is about twice what it was before the advent of modern synthetic detergents.

Coin (*36*) cites surface tension measurements made from November 1950 to November 1951 on sewage plant effluent and on the waters of the Seine, Oise, and Marne rivers in France. The sewage plant effluent consistently had a surface tension of approximately 50 dynes per centimeter. That of the river waters varied from about 70 dynes per centimeter in November 1950 to about 62–63 in November 1951.

Mackenzie (*24*) mentions foaming on rivers as a nuisance and states that it has been the subject of at least one injunction suit in court.

Degens (*37*) reports that 5 ppm of the active ingredient (surfactant) of certain syndets is lethal to tadpoles, sticklebacks, and *Daphnia* in 10–100 hr. When some types of fish are gradually acclimatized to the syndets studied, the lethal surfactant concentration varies from 9 to 36 ppm, although, if

the same kinds of fish are abruptly introduced into a water having a 5-ppm surfactant concentration, they die within a short time.

Degens also states (*37*) that anionics of the alkyl sulfate type are quickly decomposed in an aquarium tank, the surfactant content dropping from 25 to 3 ppm in 4 days, but the biological decomposition of alkyl aryl sulfonates and nonionics proceeds much more slowly, being reduced only 50 per cent in 14 days. The more persistent compounds are the ones most likely to cause water treatment problems at plants downstream from major sources of detergent pollution.

Sawyer, Lynch, and Bogan (*38*), from their as yet uncompleted investigation of the biochemical characteristics of various surfactants, have been able to make certain observations regarding the potential behavior of syndets in receiving waters: Biological degradation of alkyl sulfates would be readily achieved, whereas substances like the alkyl aryl sulfonates would be more slowly stabilized. Receiving waters given an opportunity to achieve a degree of acclimation to a decomposition-resistant compound should improve in ability to assimilate such material. Contrary to what has been widely reported, it was found that the alkyl aryl sulfonates may have a significant biochemical oxygen demand. With the acclimated seed used, 5-day BOD values up to 21.4 per cent of the theoretical complete oxidation values were obtained.

Effects on Water Treatment

Laboratory Studies

Cross (*39*) has reported on the effect of domestic and industrial synthetic detergents on the coagulation of raw Lake Michigan water. Syndets were added to the water to produce concentrations ranging from 0.1 to 5.0 ppm. When interference with coagulation did occur, it usually was not until the 5.0-ppm concentration was reached. The adjustment of pH was found to be very important. The addition of lime produced a marked improvement in the coagulation of the water, whether alum, ferric sulfate, or chlorinated copperas was used. The employment of silicate did not improve lime-alum coagulation, but, without the addition of lime, alum-silicates gave better coagulation than the other methods tested. The domestic syndets caused more interference with coagulation than the industrial type.

Results of tests (*39*) with ferric sulfate as a coagulant in the presence of synthetic detergents were similar to those with alum. Detergent interference was minimized when lime was added to bring the pH to 9.1 or higher. Similar results were obtained with chlorinated copperas.

With one domestic syndet (5.0 ppm), a good silicate floc was formed, but considerable colloidal matter was left in the water. After half an hour it was observed that floc, buoyed up by small air bubbles, was floating on the surface. At the end of 2 hr of settling, with a temperature increase of 4°C, all the floc had risen to the surface. The same results were noted for syndet concentrations of 1.0 and 3.0 ppm. [The phenomenon of rising floc was noted in connection with detergent difficulties at treatment plants in Osawatomie, Kan. (see page 769)

and Wheeling, W.Va. (see page 767). Activated silica was found to be beneficial at Osawatomie (*40*). The plant was operated for several days using 25 ppm of alum and 1 ppm of activated silica. A good, small, dense floc was obtained, and the amount of floating material was substantially reduced.]

Rising floc may be a flotation phenomenon associated with dissolved-gas liberation plus interfacial changes produced by surface-active agents in the water. Hopper and McCowen (*41*) have investigated a flotation process of water treatment that employs surface-active agents and bubble aeration. Nontoxic quaternary ammonium compounds were used in a concentration of 10 ppm, and less than 1 ppm remained in the water after flotation treatment. On a laboratory scale, the process was effective in removing bacteria, cysts, and turbidity.

Langelier and colleagues (*42*) have studied the effects of certain surface-active agents on synthetic turbid waters. These authors noted that one of the common properties of surfactants is their ability to disperse colloidal particles, thus achieving the opposite of flocculation. The various agents investigated included representatives of the anionic, cationic, and nonionic groups. Up to 50 ppm of one of the alkyl aryl sulfonates, typical of the sort of anionic surfactant now being produced in large quantities, had no effect on flocculation under the test conditions. Another anionic surfactant, alkyl aryl sulfonate, had no effect up to 17 ppm, but greater concentrations, up to 40 ppm, showed increasing interference. Raising the alum dosage from 25 to 30 ppm, however, overcame the adverse effects completely, and the resulting alum flocs were greatly increased in size and density. One nonionic agent, polyoxyethylene thioester, had no effect, but another, in a volume concentration of 40 ppm, caused complete flocculation failure. Other nonionic and anionic agents tested showed varying effects on coagulation, ranging from slight to significant. A dosage of 20 ppm of a cationic quaternary ammonium compound caused complete dispersion of a system that otherwise would have developed a good floc. These results indicate the variable effects of surface-active agents on the physicochemical properties of water.

Langelier and colleagues (*42*) also conducted coagulation studies using sequestering agents such as sodium metaphosphate. (It will be recalled that synthetic detergents may contain a high proportion of phosphate builder possessing dispersing and sequestering properties.) With sodium metaphosphate the alum dosage required for coagulation increased linearly as the concentration of metaphosphate increased. The approximate relationship was:

$$A = 4.86P + 11.2$$

in which A is the alum dosage and P the sodium metaphosphate, both in parts per million. At metaphosphate concentrations of 5 ppm or more, however, normal alum flocculation could not be obtained, regardless of the amount of alum added.

Tastes and Odors

Filicky and others (*43, 44*) found that 80 ppm of activated carbon was effective in removing taste and odor from water to which 5 ppm each of detergent and bland lard had been added. The carbon removed the taste completely and approximately 80 per

cent of the odor. With certain other detergent-lard mixtures at the 5-ppm level, less than 80 ppm of carbon was required.

Adsorption by carbon is influenced by the pH value. Detergent-lard tastes and odors were more easily adsorbed in the pH range 5–8 than at a higher pH level. Chlorination appeared to make the detergent-lard mixtures more difficult to adsorb, less activated carbon being required when

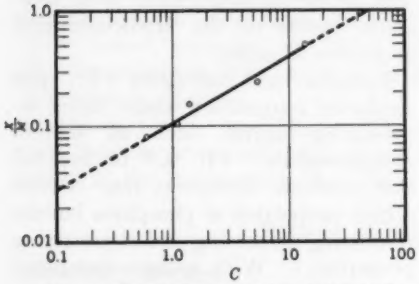


Fig. 9. Syndet Removal by Activated Carbon

The data in Table 3 are plotted to conform to the Freundlich equation:

$$\frac{X}{M} = K(C)^{\frac{1}{n}}$$

in which X *(ppm) is syndet removed,* M *(ppm) is carbon added, and* C *(ppm) is syndet remaining;* K *and* n *are constants.*

added before chlorination than after. [Culp and Stoltenberg (*40*) found chlorine dioxide, free residual chlorination, and activated carbon (40 ppm) effective against tastes and odors at the Osawatomie plant.]

The effect of various dosages of activated carbon on Lake Michigan water to which 20 ppm of a household synthetic detergent had been added is shown in Table 3 and Fig. 9. The data, which are plotted to conform to the Freundlich adsorption equation, were obtained at the Chicago South Dist. Filtration Plant laboratory.

Recent Operating Experiences

Southeastern States. Inquiries regarding synthetic-detergent troubles were sent to several large southeastern cities using surface water supplies, as well as to the state sanitary engineers in Virginia, Georgia, Mississippi, Alabama, Louisiana, Maryland, Florida, North Carolina, and South Carolina. No difficulties attributable to synthetic detergents were reported.

TABLE 3

Syndet Removal by Activated Carbon

Carbon Added (M) *ppm*	Syndet Removed (X) *ppm*	$\frac{X}{M}$	Syndet Remaining (C) *ppm*
0	0.0		20.0
12	6.0	0.500	14.0
60	14.6	0.243	5.4
120	18.6	0.155	1.4
180	18.9	0.105	1.1
240	19.4	0.0808	0.6

Ohio Valley. Similar inquiries were addressed to 30 cities in Ohio, Pennsylvania, Kentucky, and West Virginia (Wheeling was not included, as its syndet problems—described below—were already a matter of record). The cities selected all use surface water and have a population of 20,000 or more. Of 23 replying, fifteen reported negatively, while eight had difficulties that might be caused by syndets. The presence of syndets was detected either by foam or by the methylene blue test. Four of these cities reported tastes and odors and two suspected interference with iron and manganese removal.

Four had coagulation trouble. One suspected an adverse effect on distilled-water quality.

At Wheeling, syndet difficulty was first encountered in the latter part of November 1953 (*45, 46*). An unusually dry summer and fall was followed by a rainy spell during November, after which a fishy odor was detected in the water. By early December the smell had developed into what A. R. Todd, the superintendent of purification, described as a "decomposed-whale odor," suggesting not only its type but also its intensity. The raw-water basin was covered with a layer of foam more than 4 ft thick, while a 1–2-ft blanket of foam extended across the 700-ft wide Ohio River from shore to shore. Serious coagulation difficulties were encountered. The floc would not settle and large particles, held up by bubbles, floated on the water, which had a light straw color as it went through the filters. The iron content of the finished water rose to more than 0.3 ppm, and black water appeared all over the city. This discoloration was believed due to manganese and iron oxides, which seemed to be held in a peptized state by the syndets.

To remove the iron, it was necessary to raise the pH to 10.3. More than four times the normal amount of lime had to be used. (This difficulty with iron removal climaxed 18 months of trouble in producing an iron-free water at pH values of 9.0–9.3.) At 2 PM on Dec. 1, 1953, the syndet content of the raw water was 12 ppm, and the average for the day was 4 ppm. The intense fishy odor was eliminated by using 40 ppm of activated carbon or chlorine dioxide (four times the normal dosage). The taste, however, still persisted. Chlorine dioxide was apparently not effective against phenol at the high pH required for iron removal.

Consumers with cation-exchange softeners complained that regeneration was difficult, as foam developed during washing for brine removal. There were some complaints of consumers vomiting, perhaps because of the fishy odor of the water. Tropical-fish deaths were also reported.

A sample of the liquefied foam, submitted to the Pennsylvania Health Dept., was found to contain 3,800 ppm of synthetic detergent, corresponding to an anionic-surfactant content of approximately 1,250 ppm. A sample of the same liquid was sent to the Robert A. Taft Sanitary Engineering Center, US Public Health Service, Cincinnati, Ohio, where analysis indicated an anionic-surfactant content of 1,200 ppm. Spectrophotometric examination left little doubt that the Wheeling foam contained an alkyl aryl sulfonate.

TABLE 4

Syndet Concentration, Wheeling Raw Water

Date (1953)	Syndet Concentration *ppm*
Nov. 25	1
30	4
Dec. 1	4
2	12
3	4
4	4
5	3
6	1
7	trace

The syndet concentration of the raw Ohio River water at Wheeling during late November and early December 1953 is shown in Table 4. Numerous tests indicated that syndet removal at the treatment plant averaged only about 20 per cent.

Superintendent Todd summarized the experience at Wheeling in his let-

ter of Jan. 13, 1954, addressed to the Ohio River Valley Water Sanitation Commission:

> Coagulation in the presence of synthetic detergents is a nightmare. Iron salts in the presence of synthetic detergents will not precipitate out at ordinary pH. A pH of 10.3 is required. Chlorine dioxide is not effective against phenol at a pH of 10.3 or higher. It was found necessary to flocculate at a pH of 10.3–10.5, to remove iron salts; drop the pH in the next basin to 9.3 and treat with chlorine dioxide, for phenol removal; and again raise the pH to 9.5–9.8, for red water prevention. We have definitely proved to our own satisfaction that synthetic detergents increase the corrosive action of water many fold. [The latter statement may refer as much to the peptizing action of syndets on existing pipe deposits as to true corrosion.]

North Central States and Province of Ontario. In reply to task group inquiries, most of the health departments and cities in Illinois, Indiana, Iowa, Michigan, Minnesota, Wisconsin, and Ontario reported no difficulty with syndets, but the following experiences are of interest:

Appleton, Wis., reported inability to obtain proper coagulation with alum alone, presumably owing to the presence of small amounts of synthetic detergents. Ferric sulfate is used as a supplementary coagulant. Chlorine-activated silica is employed as a coagulant aid. (See also an article by Gallaher (*47*), published in 1950.)

Ottumwa, Iowa, has experienced heavy foaming for prolonged periods and some difficulty with floc settling. Its source of water supply is the Des Moines River, which has been at low stage since July 1953. All cities above Ottumwa are served by sewage treatment plants. During the low stream flow period extremely high algal counts have been encountered, with threshold odors in the raw water ranging from 50 to 130. Even with ice cover, the dissolved oxygen in the river water varied from 15 to 25 ppm. Probably the fertilizing effects of phosphate and nitrogen from the treated sewage discharged to the river contributed to the heavy algal production.

New Albany, Ind., which takes its supply from the Ohio River, encountered unusual raw-water conditions in January 1954. The water had a golden color, and light suds, which did not persist, formed in the plant mixing basin. Taste and odor conditions, described as "bad," improved somewhat when the chlorine dosage was increased. The principal consumer complaint, however, was color in the hot water. Experiments by plant personnel indicated that the color began to appear at 127°F. This condition prevailed for 2 weeks. A nonsettling, fine silt has been a continuing characteristic of the water, as has the previously mentioned sudsing. An investigation is being made by the Indiana Health Dept.

The Chicago South Dist. Filtration Plant, in November 1953, made tests on raw Lake Michigan water to which had been added an ammonium sulfate compound containing an alkyl aryl sulfonate (1.25 per cent) anticaking agent. A concentration of only 0.2 ppm alkyl aryl sulfonate (16 ppm of the compound) produced interference with the coagulation process and resulted in a disagreeable "chemical" odor. Another test was made on filtered water using only 1 ppm of the ammonium sulfate compound. When this water was chlorinated to the usual 4:1 chlorine-ammonia ratio, the same disagreeable chemical odor was produced. On the basis of the test results,

the use of the alkyl aryl sulfonate anticaking agent was disapproved.

Western States. The health departments of eighteen western states and certain cities therein were queried regarding syndets. A preliminary report indicates that the majority have encountered no difficulties. One city in Montana, however, suspects syndet trouble, and the matter is being investigated by the State Health Dept.

Synthetic-detergent concentrations in a 22-mile stretch of the Neosho River in Kansas, from Chanute downstream to Erie, were determined during January 1954 by the State Board of Health. The results obtained are shown in Table 5.

TABLE 5

Syndet Pollution, Neosho River, 1954

Source of Sample	Anionic-Syndet Content *ppm*	
	Jan. 7	Jan. 14
Chanute, Kan.		
Raw water		2.8
Tap water		2.6
Raw sewage		71.*
Treated sewage		43.*
Neosho R., 5 miles below Chanute		5.0
Erie, Kan.		
Raw water	8.4	5.5
Tap water	9.8†	6.0

* Grab samples; results do not necessarily represent removal by sewage treatment.
† Peak probably occurred Jan. 4–6, when no samples were collected.

A thin scum of floating floc that formed on the primary settling basins at Erie was objectionable only from the standpoint of appearance. The two filters at this plant are backwashed daily, and it was not necessary to change this schedule, although much more material accumulated on the filter beds between washings. The plant operators noted moderate foaming of water drawn from taps, but this condition did not cause consumer complaints. Samples of tap water shipped to the State Health Dept. laboratory foamed upon shaking. No objectionable taste was detected in the raw or treated water at Erie. The raw water had a very slight fishy odor, but the tap water was odorless. On Jan. 6, 1954, the settled water had a distinct yellow color, which was eliminated by increasing the alum dosage from 4 to 17 ppm and the chlorine dosage from 1 to 3 ppm.

Early in 1953, and again in 1954, Osawatomie, Kan., on the Marais des Cygnes River, experienced treatment plant difficulties believed to be due, at least in part, to synthetic detergents. On Mar. 31, 1954, the raw river water (temperature 50°F) had a syndet content of 7.2 ppm; the plant tap water, 6.6 ppm; and the condensed froth at the inlet flume, 12 ppm. These concentrations were considerably higher than the 1953 maximum previously reported by Culp and Stoltenberg (*40*). Unlike 1953, however, no difficulty was encountered with flocculation and settling, although considerable taste and odor and some foaming at the taps were noted. The only obvious difference in conditions that might affect flocculation and settling was the basin water temperature, which was 54°F in 1954, about 20°F higher than in 1953. The taste and odor problem was complicated by the presence of algae, which were not a factor in 1953.

Northeastern States. No difficulties have been reported to the task group from northeastern states. An intensive canvas of this section of the country has not, however, been carried out.

Effects on Sewage Treatment

Syndet Concentration in Sewage

Several writers have estimated the average concentration of synthetic detergents in sewage by computations using sales and sewage flow data. By chemical analysis of samples, Culp and Stoltenberg (*40*) found the concentration of synthetic detergent (anionic, complete product) in the raw and treated sewage at Ottawa, Kan., to be 44 and 39 ppm, respectively. Calculations based on syndet sales and sewage flow gave a figure of 53 ppm, which checks closely with the analysis value, considering that a portion of the sales was made to rural customers not served by the sewage system. Syndet concentrations in sewage at selected cities in Kansas are given in Table 6.

Sperry (*48*) calculated a value of 45 ppm for the syndet concentration in Aurora, Ill., sewage. This figure corresponds to 12.2 ppm of surfactant, based on a surfactant content of 27 per cent in synthetic detergents. Kraus (*13*) similarly estimated 13.4 ppm of surfactant at Peoria, Ill., and Bowers (*13*) computed a value of 42 ppm syndet (complete product) in Indianapolis, Ind., sewage.

Treatment Problems

The syndet effect most often mentioned by sewage plant operators has been excessive frothing on aeration tanks. The first reported occurrence of extreme frothing was at Mount Penn, Pa., in 1947 (*49*). Samples of a synthetic detergent (said to contain a nonionic surfactant) had been distributed to housewives throughout the community on a Friday. By the following Monday morning, froth 2–5 ft deep enveloped most of the mechanical-aeration activated sludge plant. After 2 weeks the froth decreased in amount, but was still evident each morning for 30 days (*50*). Frothing has been reported from many other sewage treatment plants in this country and abroad.

Froth may be an accident hazard, as it smears the tank walls and walkways with grease and sludge solids. Donaldson (*51*) stated that, in New York, froth from final tanks or effluents from the activated sludge plants contained 30–50 per cent grease, and some dried froth from tank walls contained up to 90 per cent grease. Windblown froth may be a significant health hazard, because, as Berg (*52*) states, it has been found that the bacterial counts in the foam phase are at least 20 times as great as in the liquid phase at the same relative point in the aeration tank.

Froth on aeration tanks has been controlled at various plants by means of water sprays or defoaming agents (*50–52*). There is some indication that a high concentration of mixed liquor solids in the aeration tanks may help to reduce frothing (*53*).

The evidence connecting frothing to synthetic detergents is inconclusive. Frothing has become a serious problem in many plants, however, since household synthetic detergents came into common use. The Mount Penn incident was closely related to a sudden rise in syndet usage. Wells and Scherer (*53*), in plant scale experiments at San Antonio, Tex., found that frothing could be produced at will by lowering the concentration of mixed liquor solids and that the froth disappeared as the solids concentration was increased again. Under the conditions obtaining at the time, no frothing occurred when the solids concentration

was maintained above a level of 1,400 ppm. A household detergent, added in concentrations of 12–125 ppm (mixed liquor flow), did not cause frothing when the mixed liquor solids concentration was about 3,300 ppm. Gowdy (*54*) experimented with the addition of a household synthetic detergent to a mechanical-aeration activated sludge plant at Bryan, Ohio. The mixed liquor solids concentration was 800 ppm. The detergent was added to the aeration tank influent at a rate of 100 ppm, based on sewage flow. No frothing was induced in the tank, and only minor frothing was found in the effluent channel.

TABLE 6

*Sewage Syndet Content, Kansas Cities**

City	Date (1953)	Anionic-Syndet Content *ppm*
Emporia	Mar. 6	15.
Burlington	Mar. 2	33.
Le Roy	Mar. 5	27.
Iola	Mar. 3	20.
Humboldt	Mar. 2	34.
Chanute†	Feb. 28	29.
Parsons	Mar. 4	22.
Oswego	Mar. 2	4.1
Chetopa	Mar. 7	4.6

* Treated sewage or sewage outfall (*40*).
† Compare Table 5.

Synthetic detergents have interfered with chemical coagulation and sedimentation of sewage. This difficulty has been particularly noted in the wool textile factory section of England, where sulfuric acid is used as a coagulant and as a means of "cracking" the grease emulsions from wool scouring (*55*). From a study of American treatment plant operating records, Sperry (*48*) found that the great increase in the use of household syndets in 1949 and 1950 was coincident with a reduction in the efficiency of primary sedimentation. Various investigators have reported on the effects of synthetic detergents on sludge digestion (*48, 56, 57*), activated sludge (*57, 58*), and trickling filters (*48, 55, 57, 58*).

Published data indicate that there are marked differences in the effect of biological oxidation processes of sewage treatment on different commercial surfactants. The alkyl sulfates appear to be quite responsive to biological treatment, but the alkyl aryl sulfonates have been reported to be much more resistant. Hurley (*59*), in reporting on plant scale experiments, stated that, during a period when 75 ppm of a secondary sodium alkyl sulfate was added to the sewage flow, 31 per cent of the surfactant was removed by sedimentation and 64 per cent by the trickling filters and final settling. Hurley also reported (*60*) that, when 150 ppm was added, no significant amount of the surfactant appeared in the final effluent and most of the material was removed in the top 1 ft of the filter. Degens and colleagues (*16*) stated that the alkyl sulfates were almost completely removed by biological treatment, but that a large proportion of the alkyl aryl sulfonates appeared in the final effluent. At Baltimore, 5-day sampling tests showed that 39 per cent of the initial "sulfonated surface-active compounds" was removed by primary sedimentation and trickling filters and 21 per cent by primary sedimentation–activated sludge (*61*). Lumb (*58*), experimenting with an alkyl aryl sulfonate, stated that about 60 per cent was removed by a trickling filter in the laboratory.

Little has been published regarding the effect of sewage treatment proc-

esses on nonionic detergents. Mackenzie (*24*) quotes an Imperial Chemical Industries technical monograph as stating that nonionics like ethylene oxide condensate passed through bio-aeration processes unchanged. Manganelli (*56*) experimented with the nonionic, polyoxyethylene (20) sorbitan monooleate, and reported that it was biologically oxidizable.

Areas for Further Study

Thomas (*62*) has called attention to a very important aspect of investigations on the effects of synthetic detergents on water and sewage. Much of the experimental work carried on thus far has involved the direct addition of small amounts of synthetic detergents to water or sewage. Data obtained in this manner are valuable, but it must be understood that this procedure may produce an entirely different colloidal system from that encountered in practice. In actual use in laundry and kitchen, relatively high detergent concentrations are involved, together with fairly high temperatures. Subsequently dilution and cooling occur in the sewer system. Sewage treatment results in additional changes, and there is, of course, considerable further dilution and opportunity for change in receiving waters. The resulting system may radically differ from that obtained by adding a small amount of synthetic detergent direct to sewage or raw water. As Thomas states, "It is axiomatic in colloid chemistry that the manner of preparation of a sol may be as important in determining its properties as are its chemical constituents."

The following are believed to be important areas for further study. This task group would appreciate the opportunity of corresponding with and receiving reports from those working on these or other phases of the synthetic-detergent problem:

1. Analytical methods, including analytical standards
2. Data on the surfactant and phosphate content of surface waters used as supply sources
3. Effects of synthetic detergents (complete product) and individual components on water quality and water treatment processes
4. Effects of water and sewage treatment processes on synthetic-detergent constituents
5. Persistence and fate of the major components of synthetic detergents in surface waters
6. Toxicity data.

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Studies on Plastic Pipe for Potable Water Supplies

By Walter D. Tiedeman

A paper presented on May 25, 1954, at the Annual Conference, Seattle, Wash., by Walter D. Tiedeman, Exec. Director, National Sanitation Foundation Testing Lab., School of Public Health, Univ. of Michigan, Ann Arbor, Mich.

THERE is a growing interest in the use of plastic pipe for underground water lines because it has a number of desirable characteristics, including noncorrosiveness, light weight, and ease of installation. For the past 2 years a study of selected samples of plastic pipe has been in progress at the laboratory of the National Sanitation Foundation in the School of Public Health, University of Michigan, Ann Arbor, Mich. The tests applied are designed to determine possible effects of plastic pipe upon the safety, quality, and palatability of water delivered through it, as well as possible deleterious effects of the water upon such pipe. It is recognized that water works men are greatly interested also in the physical properties and in the standardization of the sizes of such pipe and fittings. These two factors are being given separate consideration by other agencies.

The term "plastic" is defined in one technical dictionary as "a substance that can be molded." Obviously this definition would include glass, concrete, clay, bronze, lead, steel, and many other substances. *Webster's New Collegiate Dictionary* defines it somewhat more precisely as "any of a large group of organic, synthetic, or processed materials that are molded or cast and used for making many kinds of small articles, cabinets, airplane bodies, etc., in varnishes, etc., and as a substitute for glass. Some are cellulose derivatives, some proteins, and many are resins formed by chemical condensation or polymerization. Rubber and similar materials (as neoprene) are sometimes included among plastics. Plastics are commonly known by their trademark names." This definition limits the field but still covers a wide category of materials with varying chemical and physical properties. A plastic may have only a few simple ingredients or may contain many:

1. A *resin* or *cellulose derivative* is a principal ingredient. The resins may be of vegetable or animal origin or synthetic.

2. *Coloring material,* such as carbon black, is frequently used in plastic pipe to prevent the possibly deleterious effect of long exposure to ultraviolet light.

3. A *mold lubricant* may be added to prevent the plastic from sticking to the mold as the pipe is extruded. This substance may be a soap of a heavy metal.

4. A *plasticizer* also may be added to soften, increase toughness, or otherwise modify the properties of the

plastic. Examples include esters of phosphoric, phthalic, and other acids.

5. An *antioxidant,* such as phenylnaphthylamine, sometimes is required, to prevent or slow down oxidation.

6. Depending upon the type of plastic, an *accelerator* may be necessary, to aid in or speed up the vulcanization of rubber. Antimony pentasulfide or hexamethylenetetraamine may be used for this purpose.

7. A *stabilizer* also may be used, to retard degradation due to heat or light, as well as to maintain emulsions.

8. Another ingredient may be a *filler*—a cheap substance providing body, strength, or other properties.

The preceding list serves to stress the complexity of the problem and the need for some definite and dependable means of identifying pipe used in the field.

Materials and Water Studied

The 23 samples of plastic pipe subjected to testing may be classified in four general groups, according to the basic resins used. Four samples were polyethylene, nine were rubber-modified polystyrene, seven were polyvinyl chloride (including saran), and three were cellulose acetate butyrate. These include all of the types of plastic pipe now being marketed for water supply use in the United States.

Considerable variations in sizes and wall thicknesses were noted in the samples of pipe submitted, although 1-in. ID pipe had been requested. Fittings also varied materially. Furthermore, wide variations were observed in physical properties, which, as previously stated, are not covered by these tests.

It is possible to make approximate identifications of these groups of plastics on the basis of the simple determination of specific gravity. The polyethylenes, with 0.91–0.94 sp gr, normally will float in water. The rubber-modified polystyrene group has a mean sp gr of 1.05, with a range of 1.03–1.09. The cellulose acetate butyrates have an average sp gr of 1.16, varying from 1.10 to 1.19. The polyvinyl chlorides average 1.40, varying from 1.35 to 1.5 (except saran, which has a sp gr of 1.74).

One of the primary considerations in this program was the selection of a water supply, to be used throughout the tests, that would be as aggressive as any natural water is likely to be. It obviously would have been too time consuming and expensive to conduct all of the tests with a number of different water supplies. A variety of waters selected for high content of ingredients such as chlorides, sulfates, bicarbonates, iron, fluorides, and free carbon dioxide were compared for their effect on plastic. The composition of some of these waters is given in Table I.

In all of these tests, it appeared that low pH and, possibly, residual chlorine and fluoride were the factors influencing the extraction of substances from plastic pipe. This observation led to further tests using treated (including fluoridation) Ann Arbor city water, the pH of which was lowered to approximately 5.0 by the addition of free carbon dioxide. Equivalent results could be obtained by using demineralized water, adding 0.5 ppm residual chlorine (orthotolidine-arsenite test) and 2.0 ppm fluoride, with the pH similarly adjusted to 5.0 or less.

Extraction Tests

Because the basic materials for plastic pipe are furnished by suppliers to extruders who may add other ingredients, particularly mold lubricants, it

was considered necessary to work with the finished plastic pipe and not with the principal plastic components. A circular power saw was used to cut the plastic pipe into ⅛-in. thick rings, which, in turn, were quartered. The exposed surface area was calculated and the weight was determined for test plastic to give approximately 600 sq cm of total exposed surface.

It appeared desirable to accelerate any action by warming the water somewhat, without raising it to a temperature that would affect the physical characteristics of the plastic. The temperature of 35°C, commonly used

TABLE 1

Analyses of Waters Selected for Testing

Item	Michigan*					Illinois†		
	Ann Arbor	Clio	Dexter	East Lansing	Milan	Deland	Benton	Enfield
	Concentration—*ppm*							
SiO_2	8.0	10.4	8.8	8.0	10.4	20	2	11
Fe	0	0.06	1.70	0.11	0.98	5.1	0.5	0.06
Mn						0.02	0.5+	0.15
Ca	16.0	70.0	92.5	20.5	70.0	107	24	4
Mg	10.4	18.0	25.6	7.7	26.8	57	15	2.4
Na						122	41	270
Na+K	118.8	125.0	14.2	150.0	7.5			
Cl	10.0	110.0	12.0	52.5	11.0	14	65	150
F	1.0‡	0.9				0.3	0.1	3.0
SO_4	78.0	140.0	84.0	18.8	5.6	0	78	35
NO_3						0	0	0
Free CO_2						568		
HCO_3	10.9	330.0	316.5	364.0	342.5			
Hardness								
Carbonate						501	38	20
Noncarbonate						0	84	0
Total ($CaCO_3$)	77	249	335	88	280	501	122	20
Alkalinity ($CaCO_3$)						710	38	890
Total solids	176	646	410	450	282			
Residual solids						693	270	1,240
pH						6.2	7.5	8.4

* Reported by State Dept. of Health.
† Reported by San. Eng. Labs., State Dept. of Public Health.
‡ Includes 0.25 natural and 0.75 added.

each sample of plastic. For test purposes, the ratio of exposed surface area to water volume was approximately the same as in a length of 1-in. ID pipe. In the extraction tests, 400 ml of each water to be tested was placed in a 1-pint glass-covered, rubber-sealed glass fruit jar with enough segmented for incubating bacteriological samples, served the purpose very well and was used throughout. At first the test jars were placed in a "Launder-ometer" * under constant agitation for about 8 hr with the temperature maintained at

* A product of Atlas Electric Services Co., Chicago.

TABLE 2

*Typical Extraction Test Results**

Plastic Pipe No.	Color *ppm*	Turbidity *ppm*	Odor	Taste‡	Total Solids		Alkalinity		pH	Fe *ppm*	Al *ppm*	NO_2 *ppm*	NO_3 *ppm*	Cl *ppm*	SO_4 *ppm*	Total Hardness *ppm*	Residual Cl *ppm*	DO *ppm*
					Residual *ppm*	Dissolved *ppm*	Phenolphthalein *ppm*	Total *ppm*										
none	6	3	0	0	152	156	10	36	9.70	0.1	0.003	0.02	0.02	10.9	53.9	95	0.3	11.2
C†	6	5	0	0	168	172	11	35	9.70	0.1	0.003	0.03	0.15	10.9	54.7	108	0.02	8.4
120	8	5	0	med	164	164	10	40	9.65	0.1	0.003	trace	0.08	12.4	54.2	110	0.01	9.0
160	6	7	0	m	172	176	10	39	9.65	0.25	0.014	0.01	0.04	11.5	56.2	97	0.01	9.6
170	6	6	0	med	176	172	9	36	9.60	0.1	0.003	0.04	0.05	11.8	55.2	102	0.01	9.8
none	0	5	0	0	176	176	23	62	9.90	0	0	0.01	0.02	10.9	64.3	114	0.15	10.8
C†	0	5	0	0	176	192	20	59	9.70	0	0	0.0	0.04	10.9	62.9	114	0.01	6.6
110	0	5	6.7	med	184	184	21	60	9.85	0.2	0	0.1	0.02	10.2	64.3	116	0	8.6
150	0	5	0	med	188	176	20	58	9.85	trace	0	0.1	0.02	12.1	71.0	118	0.01	9.0
180	0	7	2	med	184	182	20	58	9.75	0	0	0.2	0.02	12.1	63.4	114	0	8.2
none	0	1		0	144	144	24	54	9.50	0.1	0	0.002	0.12	10.9	48.2	90	0.8	9.8
C†	0	2		0	160	128	12	50	9.45	trace	0	0.004	0.20	10.9	41.3	92	0	9.2
200	2	2		med	168	140	8	42	9.22	0.1	0	0.004	0.28	10.3	49.4	90	0	9.0
210	0	3	17	med	168	144	6	46	9.20	0.1	0	0.005	0.16	10.7	34.1	91	0	9.0
220	0	1		med	160	148	24	68	9.50	trace	0	0.005	0.40	10.7	44.2	92	0.3	9.2

* Ann Arbor water used; contact time, 10 hr with constant agitation, 14 hr with no agitation; temperature, 35°C; tests run for lead and copper were all negative.
† Control (contact with pipe material other than plastic).
‡ Key: med—medicinal, m—musty.

35°C by hot water under thermostatic control. This piece of equipment soon became a bottleneck because of its limited capacity. Further tests showed that satisfactory results could be obtained simply by holding the jars for 3 days in a walk-in incubator at 35°C, inverting each jar ten times every 8 hr.

The results of the physical and chemical tests show that no undesirable substances were extracted from the plastic pipe studied, with the exception of three samples that were submitted because they were known to contain substances which might be extractable. Some typical results of these extraction tests are shown in Table 2.

One of the samples, which was made from cable scrap, imparted a color of 25–35 to the test water. The color was described as orange brown. Although there is no evidence that any harmful substance was thus introduced into the water, this finding supports manufacturers' recommendations against water works use of pipe made from cable scrap.

With a test water of pH 9.6, it was found possible to extract 0.34 ppm of lead from a sample of plastic pipe in which a complex lead compound was used as a stabilizer. When the pH of the test water was lowered to 1.0 by the addition of hydrochloric acid, 2 ppm of lead was extracted. Of course, this result was obtained under extreme conditions of temperature, length of contact, and amount of plastic exposed per unit volume of test water. The validity of the test procedure was checked by means of plastic test specimens prepared especially for this investigation with unreasonably large quantities (5 and 10 per cent) of lead stabilizer. It was possible, with the acidified test water, to extract 5.5 and 6.5 ppm lead, respectively, from these special compounds. It is likely that the quantity of lead available for extraction is no greater in a plastic pipe containing a normal amount of stabilizer than it would be in a system of galvanized-steel piping made up with liberal amounts of red or white lead as the jointing compound.

Some other changes in chemical composition of test waters were observed but were not considered to be of significance. For instance, in extractions with one water supply having an iron content of 2.85 ppm and a color of 60 (apparently due to the iron), the color was reduced to 10 and the iron to 0.1 ppm after contact with a rubber-modified polystyrene sample. The control sample of water subjected to the same procedure of storage and agitation did not show any reduction in iron or color.

Taste and Odor

To investigate taste and odor effects, two test procedures were employed: the previously described extraction method and the recirculation of water for long periods through a system of plastic pipe containing fittings applied with recommended jointing compounds. A panel of five persons was selected on the basis of preliminary tests of their ability to detect odors. All samples were presented to the panel members as unknowns identified simply by number. Controls consisted of water subjected to the extraction test conditions except for contact with plastic samples, as well as water recirculated through a system of galvanized steel piping. Standard methods were followed in these tests, as in all others. Some typical results are shown in Table 3.

One really pronounced odor was detected in a 1:149 dilution with odor-free water by four out of the five panel members, while the fifth member de-

TABLE 3—*Typical Taste and Odor Panel Results*

Panel Member	Test Plastic No.	Dilution	Threshold Odor No.	Nature of Odor	Geometric Mean Threshold Odor No.	Taste (Undiluted Sample)
A	110*	5+145	30.0	medicinal		musty, wet cardboard
B		25+125	6.0	medicinal		bitter
C		25+125	6.0	medicinal	12	sewage
D		10+140	15.0	disagreeable		bitter (slight)
E		10+140	15.0	sweet		medicinal (ether)
A	140*	5+125	30.0	metallic		none
B		25+125	6.0	disagreeable		nonobjectionable
C		none	1.0	medicinal	7	flat
D		25+125	6.0	fruity		sweet
E		10+140	15.0	earthy		flat, tasteless
A	150*	5+145	30.0	slightly disagreeable		sweet
B		5+145	30.0	sweetish		musty
C		none	1.0	medicinal	11	none
D		10+140	15.0	moldy		sweet (slightly objectionable)
E		none	none			acid (slight)
A	200*	50+100	3.0	medicinal		halogen
B		25+125	6.0	medicinal		phenolic
C		50+125	3.0	medicinal	6	flat
D		50+125	30.0	sweet		bitter (slight)
E		none				not describable
A	C*†	5+145	30.0	musty		not describable
B		50+100	3.0	moldy		flat
C		25+125	6.0	fruity	10	applelike
D		10+140	15.0	disagreeable		bitter (very objectionable)
E		none				none
A	U*‡	none	none			salty
B		none	1.0	medicinal		tasteless
C		25+125	6.0	sweet	3	none
D		25+125	6.0	medicinal		acid (slight)
E		25+125	6.0	musty		tasteless
A	280§	10+140	15.0	disagreeable		chlorinous
B		25+125	6.0	disagreeable		sweet
C		50+100	3.0	lake water	6	phenolic-medicinal
D		5+145	30.0	disagreeable		bitter-puckery
E		none	1.0	musty		tasteless
A	290§	25+125	6.0	sharp		halogen
B		none	1.0	disagreeable		phenolic (slight)
C		none	1.0	sweet	2	none
D		50−100	3.0	sweet		sweet (slight)
E		50−100	3.0	musty		tasteless
A	C†§	5+145	30.0	disagreeable		flat
B		none	none			tasteless
C		5+145	30.0	sweet	25	none
D		10+140	15.0	disagreeable		puckery
E		5+145	30.0	fruity		medicinal (slight)

* Deland, Ill., water used; 3-day contact with plastic (except control); 35°C.
† Control. ‡ Untreated water.
§ Ann Arbor, Mich., water used; 3-day contact with plastic (except control); 35°C.

tected it in a dilution of 10:140. This odor was in water recirculated through a system of pipe and fittings made up of a test sample of cellulose acetate butyrate. The cause was found to be butyl acetate, a water-insoluble solvent used in the jointing cement. It was learned that the odor could be practically eliminated by blowing air through the newly assembled system of piping until no odor was detectable at the outlet, and then flushing the system with a mild detergent solution, followed by a clear-water flush. After this treatment the geometric-mean threshold odor number obtained by the panel was reduced from 95 to 19, or about the same order of intensity—though not the same type—as the odor imparted to the water by the galvanized-steel recirculating system used as the control. It is quite likely that, in the latter, the odor is caused largely by the jointing compound, although the test was performed months after the system was put together and followed repeated flushing.

In general, the odors found in water exposed to plastics did not differ greatly in description from those in the control samples (water alone or in contact with galvanized-steel and copper pipe). It is quite likely that a "chemical" odor ascribed both to the control and to the plastic-pipe water samples is related to chlorination.

Although taste tests were conducted, the tastes were of a low order of intensity and were unavoidably influenced to a considerable extent by odor. The results are not considered significant.

Maintenance of Chlorine Residuals

Tests were run to determine the possible effect of plastic pipe on maintaining chlorine residuals in the water therein. There was no significant tendency for residuals to decrease more rapidly in water in contact with plastic than with copper pipe.

Pipeline Disinfection

The possibilities of disinfecting a system using plastic pipe were studied. Several recirculating systems were set up and filled with water heavily seeded with *Esch. coli.* The system then was drained and filled with fresh water containing 25 ppm of hypochlorite, in accordance with AWWA recommendations (*1*) for the disinfection of new water supply lines. The water was recirculated for 15 hr, using a stainless-steel milk pump controlled by a time switch operating alternately 30 min on and 30 min off. The concentration of coliform organisms in the seeded water varied from 2,200,000 to 2,800,000 per milliliter. At the end of the 15-hr period the chlorinated water was drained; the system was flushed with clean tap water and then refilled with dechlorinated water; the latter was also recirculated and was sampled at the beginning and end of the draining period. Coliform-organism determinations were made on each sample, using both violet-red bile agar plates and five 10-ml, five 1-ml, and five 0.1-ml portions of water in lactose broth fermentation tubes; 1-liter samples were put through the membrane filter. Completely negative results were obtained.

Toxicity to Rats

With the thought in mind that, from a sample of plastic pipe, some substance might be extracted for which no chemical test was made or which was present in too small a quantity to be detected by the technique used, rat colonies were given water that had been in prolonged contact with plastic pipe. In order to keep the number of test

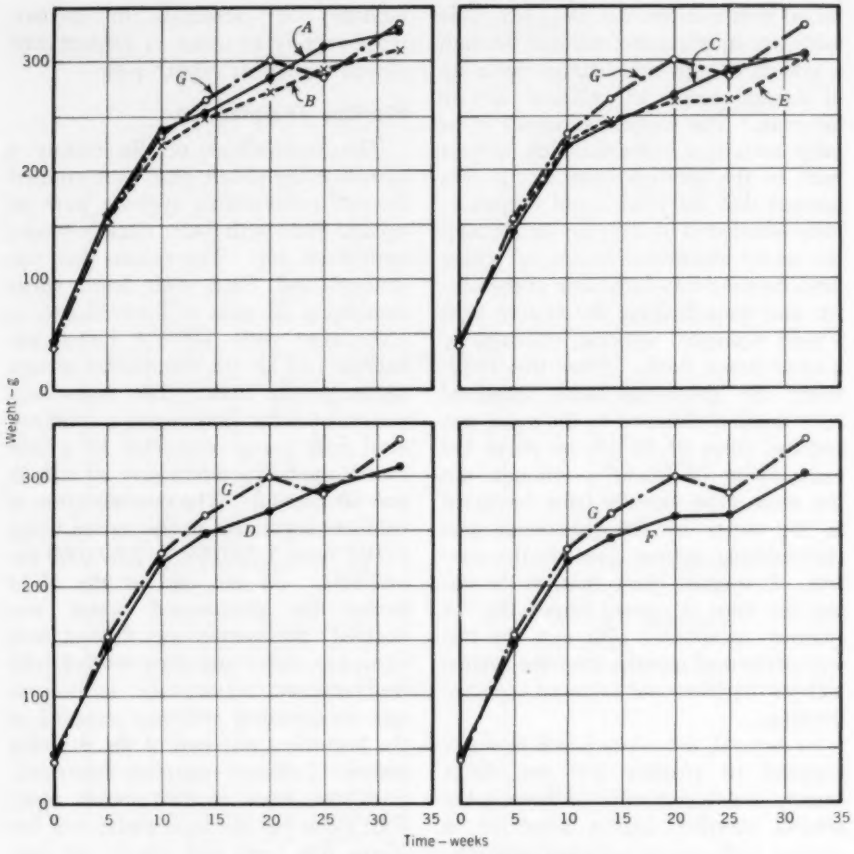

Fig. 1. Seven-Month Rat Growth Curves

All rat colonies drank Ann Arbor water that had been exposed to various types of plastic, except for Group F *(exposed to copper) and Group* G *(not exposed to pipe). For explanation of other group letters, see Table 4.*

animals within reason, the 23 samples of plastic pipe submitted for testing were grouped according to basic components and the possibility of containing extractable or toxic ingredients. Group *A* included three samples of polyethylene pipe; Group *B*, nine samples of pipe classified as rubber-modified polystyrene; Group *C*, five samples of polyvinyl chloride pipe; Group *D*, three samples of cellulose acetate butyrate pipe; and Group *E*, a special sample of polyethylene pipe from which color had been extracted and two special samples of polyvinyl chloride pipe, one containing a small percentage of lead stabilizer and the other cadmium.

Seven colonies, each consisting of five male and five female weanling albino rats, were established. All were fed the same basic ration. Five of

these colonies received only test water that had been in prolonged contact (under standardized procedure) with plastic pipe of each of the five groups listed above. The other two colonies were used as controls, Group *F* receiving only test water that had been in contact with copper pipe under conditions similar to those for plastic pipe, and Group *G* receiving test water not exposed to pipe.

The growth curves of these rats for the first 7 months of feeding are depicted in Fig. 1. All of the groups show similar, normal rates of growth. Records of daily consumption of food and water by all of the rats indicate no significant differences. The results of the examination of specimens of blood drawn from the rats in the various groups at the end of 7 months' feeding are shown in Table 4. These data likewise do not reveal any abnormal tendencies.

At the end of 6 months one rat from each group was sacrificed, and the heart, lungs, liver, spleen, kidney, adrenal, pancreas, and bowel were examined. Evidence of mild bronchial pneumonia was found in one rat from Group *A*, but there was no indication that this condition was induced by the water consumed. All other autopsies showed no significant lesions. It is planned to continue the rat feeding for a full 18 months, sacrificing one rat from each group for autopsy at the end of 12 months' feeding and the remainder at 18 months.

Attacks by Rodents

Tests were performed to determine whether brown rats, *Rattus norvegicus,* and black rats, *Rattus rattus,* would eat plastic pipe. After these rats had been trained to travel a certain passage for their food, an obstruction consisting of bars of 1-in. ID plastic pipe was so placed as to prevent their access to food. At first none of the plastic pipe was gnawed, apparently because of its large diameter and the lack of a biting edge. Later, in one instance, a gnawing edge was established by scraping the surface, and a piece of pipe was cut through by black rats. When the bars were cut to expose a biting edge, both the brown and the black rats neatly chiseled openings large enough to allow passage to their food. Sizable piles of plastic chips were recovered, but there is no evidence that any of the plastic was eaten by the rats.

Long-Term Exposure

Sections of the plastic pipe from all of the samples, together with similar sections of copper and galvanized-steel pipe, were exposed to weathering outdoors, in accordance with standardized procedure, for a period of a year. Careful weighings, before and after exposure, were made of these samples, following washing and desiccation. The only significant effects were a decrease in weight of about 3 per cent in one of the samples of cellulose acetate butyrate pipe (confirmed by a duplicate sample) and a confirmed increase of about 1 per cent in one sample of rubber-modified polystyrene pipe. These samples showed slight changes in color, as well as slight film formation on exposed surfaces. The copper and galvanized-steel pipe controls also showed discoloration and film formation.

Samples of plastic pipe were exposed for 1 year at 35°C to test water and air in sealed jars. Weighings and careful observations were made and recorded. In general, the plastic samples showed less change in appearance at the interfaces than did the copper and galvanized-steel pipe controls. One

sample of rubber-modified polystyrene had a considerable increase in weight. Copper tubing similarly immersed showed fine black sediment, and galvanized-steel pipe was covered with a heavy white deposit. Microscopic examination of the water in which the specimens had been held uncovered the existence of fungus growth in the water in contact with two of the samples of cellulose acetate butyrate, three of the samples of rubber-modified polystyrene, three of the samples of polyethylene, and one of the samples of polyvinyl chloride.

The effect of exposure to an aggressive soil also was tested, by burying samples in open glass jars containing soil from a chemical-products plant. The soil had a pH of 2.0, and the temperature of the jars was kept at 35°C. To simulate rainfall, the soil was intermittently wetted with distilled water and allowed to dry. The sample of rubber-modified polystyrene pipe that gained weight on immersion in water showed an increase of about 1.6 per cent in weight after burial in this soil. A number of the samples of plastic pipe exhibited no perceptible effects, while others showed some film formation at the interfaces. Copper pipe similarly buried showed considerable oxidation and deposition of film, while galvanized-steel pipe had pronounced chemical deposits at the soil-metal interface.

Summary and Conclusions

This paper deals specifically with results obtained in testing 23 different samples of plastic pipe extruded from definite formulations classified as polyethylene, polyvinyl chloride (including saran), rubber-modified polystyrene, and cellulose acetate butyrate.

Extended tests using segmented pipe in prolonged contact with aggressive natural and fortified waters in jars showed that the most aggressive water was one with the pH adjusted to about 5 by adding carbon dioxide. It was demonstrated that this water would extract lead compounds from specially prepared test plastics and would extract color from a special test sample made of cable scrap. No objectionable substances were, however, extracted from the type of pipe recommended by manufacturers for use with potable water supplies.

Samples of plastic pipe exposed to natural weathering for a period of a year under standardized conditions showed only slight changes. There

TABLE 4

Effect of Plastic-exposed Water on Rats (Blood Test Results)

Group*	Time Since Test Began *months*	Red Blood Cells† *10^6/cu mm*	Hemoglobin† *per cent‡*	White Blood Cells† *10^3/cu mm*
A	0	7.4		22.0
	7	8.3	94.6	14.6
B	0	8.1		16.9
	7	8.6	105.0	15.7
C	0	10.0		16.8
	7	8.7	103.2	16.0
D	0	9.98		11.9
	7	8.10	102.0	15.6
E	0	8.9		15.5
	7	8.6	109.3	16.0
F	0	9.5		17.5
	7	8.7	104.2	13.7
G	0	8.6		19.0
	7	8.1	96.5	14.0

* All rats drank Ann Arbor water exposed to: *A*—polyethylene; *B*—rubber-modified polystyrene; *C*—polyvinyl chloride; *D*—cellulose acetate butyrate; *E*—miscellaneous plastic pipes (No. 130, 280, and 290); *F*—copper; *G*—no pipe (control).

† Mean values.

‡ 100 per cent equals 14.5 g.

were changes in color in a number of instances, and a fine surface film formed on the samples of rubber-modified polystyrene. Samples buried in an acid soil and kept at 35°C for a year, with intermittent wetting and drying, showed very little effect on the plastic. Some discoloration was noted, as well as a tendency to form a film. Strips of plastic pipe held partially immersed in the test water in sealed jars at 35°C for a year showed slight color changes and slight film formation. Under similar conditions, copper and galvanized-steel pipe were generally more affected than the plastic.

Portions of the test water, after having been in contact with cut plastic pipe for 3 days at 35°C, with occasional agitation, were submitted with unexposed and copper-exposed control samples to a five-member panel for taste and odor determinations. The tastes and odors of the plastic-exposed water were not found to be any more pronounced than those of the controls. There was a tendency to describe all such faint tastes and odors as chemical and medicinal, which may have been due partly to the fact that the test water was chlorinated.

Test water was recirculated for extended periods by pumping it through systems of plastic pipe to simulate conditions in a water system. During the test period the water was alternately pumped for 30 min and allowed to stand quiescent for 30 min. This method made it possible to judge the effect of fittings and jointing materials on palatability. The tastes and odors of water from these systems were insignificant, except for a cellulose acetate butyrate pipe system in which a volatile jointing material had been used. Even in that system, the odor was reduced to insignificance by emptying and flushing it with air.

Recirculating systems of each of the four general types of plastic were heavily seeded with a culture of *Esch. coli*. After prolonged exposure the system was disinfected with a solution of 25 ppm hypochlorite, flushed, and filled with fresh water. Samples of this water were examined and found negative for coliform organisms. The results indicate that such systems can be satisfactorily disinfected by this procedure.

Rat colonies were supplied with water that had been in contact with various samples of plastic pipe. During the first 6 months these rats showed normal growth and no particularly abnormal conditions. At the end of that time one rat from each colony was sacrificed and subjected to autopsy. The results showed one incidental pneumonia infection but no significant lesions in any of the vital organs or glands.

A procedure applicable by the author's or other laboratories was developed for testing plastic pipe. To meet an evident need, plastic-pipe extruders and material suppliers sponsoring the National Sanitation Foundation research program are presently working on a system of identifying plastic pipe made in accordance with formulas that have been tested and found satisfactory, from a health standpoint, for use with potable water supplies. The method of identification—perhaps in the form of a hallmark imprinted on the pipe—will be given wide publicity when a final decision on the matter has been reached.

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Discussion

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As a group, the manufacturers of thermoplastic pipe* are faced with two rather contradictory problems. The first is to establish standards for the protection of the public and to facilitate the writing of specifications and codes on the use of plastic pipe. The second is to make sure that the standards for this new product are not frozen at levels lower than necessary.

To solve these problems, the manufacturers have formed the Thermoplastic Pipe Div. of the Society of the Plastics Industry. One of the first actions of this group was to establish a standard for sizes and working pressures for polyethylene pipe, the flexible variety most commonly brought to mind by the term "plastic pipe." A formal request has been made to the US Dept. of Commerce to promulgate these specifications as a commercial standard. Moreover, the writer believes that, very shortly, the group will decide on some means of identifying polyethylene pipe meeting these and National Sanitation Foundation standards, so that the purchaser can be certain of what he is getting.

These developments, of course, are only a step along the way. Too little is actually known about the various

* Another type of plastic pipe, made of fiber glass reinforced with polyester resins, shows promise but is still in the experimental stage. The writer is not qualified to discuss this type.

plastics from a truly engineering point of view. For example, the writer's company, in its own laboratory, has found that the present ASTM methods of determining the tensile strength of plastics do not permit an accurate calculation of the lifetime strength of a a piece of steel pipe. Most of the major extruders probably agree with that statement, but, owing to the uncertainty, some of the smaller and more recently established extruders of plastic pipe quite honestly make claims for their product which are based on short-term properties certified by material manufacturers and are not applicable to pipe use. It is wise to look very carefully at plastic pipe for which extravagant claims seem to be made.

Another problem facing the extruders of plastic pipe is the need for tests, short of destruction, that can detect manufacturing flaws before the pipe is approved for use. The writer's company, in addition to a careful inspection, tests specimens at greater than recommended working pressures for 8 hr. Neither this nor other test methods now in use are completely satisfactory.

In an effort to solve these physical problems, and to arrive at proper test methods, most of the members of the Thermoplastic Pipe Div., together with the majority of the manufacturers of materials that can be used in the extrusion of plastic pipe, have initiated an expensive, long-term research program at the Battelle Memorial Institute, Columbus, Ohio, the largest nonprofit engineering research institute in the country. In addition, committees of the American Gas Assn., the National Assn. of Corrosion Engrs., and the American Petroleum Institute are working on plastic pipe with members of the industry. Other organizations about to become active in this field are the American Society for Testing Materials and the American Standards Assn.

All of these committees, dealing more or less with the same problems, take up a great deal of the time of the more industry-minded plastic extruders. It would be beneficial to centralize these efforts in one committee. Thus, by using the combined knowledge of the various groups concerned, it should be possible not only to arrive at specifications that are fair to both manufacturers and consumers of present plastic pipes, but also to devise procedures for quickly developing reasonable specifications for pipe made of the improved plastic materials that will undoubtedly appear in the future.

Metropolitan Water System Organization and Functions

Panel Discussion

A panel discussion presented on May 26, 1954, at the Annual Conference, Seattle, Wash. (John W. McFarland's portion of the discussion, published as a separate paper under the title "Organization and Activities of the East Bay Municipal Utility District" [June 1954 Journal, Vol. 46, p. 567], is omitted here.)

Legislative and Management Aspects—*Ernest H. Campbell*

A paper presented by Ernest H. Campbell, Asst. Director, Bureau of Governmental Research & Services, Univ. of Washington, Seattle, Wash.

ONE of the great challenges that confronts the nation today is how to achieve a higher degree of integration governmentally in metropolitan areas that are units physically, economically, and socially. A searching and comprehensive analysis of both the immediate and the ultimate needs of each such area, as well as imagination, perseverance, and vision, is required, to determine a suitable, workable basis upon which to proceed. Also essential is the creation of a climate of public opinion favorable to the method selected to attain this objective.

A number of factors have contributed to a growing conviction in the Pacific Northwest that the government of metropolitan areas needs to be reexamined, particularly in the Seattle–King County, Wash., area, in which more than 725,000 people reside. With respect to water supply, some of these factors are:

1. The geographical boundaries of watershed areas do not follow the political boundaries of cities and towns, counties, and water districts.

2. Increasing competition between cities and other political subdivisions for water rights and allocation of available water supply for domestic and industrial use, hydroelectric power, sewage disposal and prevention of pollution, flood control, fisheries propagation, irrigation, and other uses is generating friction.

3. The present piecemeal system of supplying water has resulted in inadequate and incompatible facilities and consequent inequitable distribution and allotments of water.*

4. The proper allocation and distribution of water in the most economical manner so as to avoid waste requires planning on a metropolitan areawide basis, particularly in view of the ever increasing consumption of wa-

* In the state of Washington there are more than 100 water districts, 190 municipal water systems, 96 private water companies subject to the jurisdiction of the public service commission, and 38 major watersheds.

ter and the relationship that water requirements bear to the ultimate land use pattern of the area.

5. Because, under existing law in Washington and other states, the primary responsibility of a city owning a municipal water system is to serve its own inhabitants and to sell only surplus water outside of its corporate limits (*1*), other cities, water districts, and unincorporated areas are reluctant to rely upon it for their water supply, and some cities hesitate to acquire a water distribution system because the sole source of an adequate water supply and the privilege of filing for a water right may be in another city's control.

6. Auxiliary systems are necessary to insure proper water storage and pressure, but the establishment of such a system, involving the construction of dams and the development of water supply sources, requires an additional tax base, and therefore would entail too great expense for most cities and other political subdivisions.

7. Substantial savings in capital expenditure and in costs of administration could be effected through integration.

8. The charging of higher rates to nonresident than to resident users and the wholesale outside-city rates develop frictions between cities with water systems and their nonresident customers (*2*).

9. In view of existing limitations upon cities in exercising police power beyond their corporate limits, they may be obliged to have some of their personnel made deputy sheriffs in order to police their watersheds (*3*).

10. The great increase in the population of the Pacific Northwest, particularly in Washington and Oregon, during the period from 1940 to 1950, and the forecasts of continuing growth, presage an accentuation of existing problems (*4*).*

In addressing attention to the problem of how to achieve an effective and proper distribution of water so as to avoid a deficiency in certain areas and a surplus in others and to insure the orderly and appropriate administration thereof in metropolitan areas, a number of governmental arrangements, individually or in combination, may be considered. No single, universal formula, however, may be applied to all areas. Although problems of metropolitan government in the United States have a number of common features, each area has some characteristics and problems of its own, and therefore its particular background, traditions, and political situation must be taken into account. A plan should be determined upon only after a searching analysis of available surface and underground water resources has been made and the present and potential needs of a given area have been comprehensively studied. Some of the governmental arrangements that can be employed, adapted, or combined to attain the desired objectives are described below.

Annexation

Annexation of a substantial portion of the metropolitan area by the central city may be utilized for adjacent unincorporated fringe areas, but, where incorporated suburbs exist, annexation has its limitations as a solution to the problem. Moreover, the area annexed usually imposes a heavy finan-

* During the period 1940–50 the population of Washington increased 37 per cent; Oregon, 39.6 per cent; and Idaho, 12.1 per cent.

cial burden upon the central city. Existing annexation legislation should be amended to permit the legislative body of a city to initiate annexation of an area which would become effective only upon a favorable vote within the area proposed for annexation. Cities should have a competent staff to make a careful study of proposed annexations, in order to determine what areas should be annexed in the interest of orderly administration, and to avoid annexation on a haphazard basis as is now usual.

Metropolitan Districts

Metropolitan districts may be established to carry on water, sewerage, and refuse disposal functions common to the area. Although such districts may provide unified management and effect major economies in supplying utility services, apprehension has been expressed that a metropolitan utility district, particularly if it is a single-function district, might tend to do its work without regard to the overall community needs. In many circles, metropolitan utility districts, especially if they may not embrace more than one county (as is permitted (*5*) under California law), have been viewed as short-term expedients until complete integration of the central city and its fringe area can be effected. The opinion exists that there are already too many special districts and that, therefore, metropolitan districts should not be created. For example, King County, Wash., has 193 special districts and their number is increasing annually; the total for the entire state of Washington is more than 1,650. In any event, enabling legislation would have to be enacted in the states comprising the Pacific Northwest to provide for the administrative structure of single- or multiple-purpose metropolitan districts, the adjustment of the assets and liabilities of systems embraced by them, and the establishment of an adequate financial structure principally based upon revenue and assessments.

Canada furnishes two notable examples of water districts. The Greater Vancouver Water Dist., organized in 1926 pursuant to an act (*6*) of the legislature of British Columbia, serves fourteen municipalities with a total estimated population of 589,000 and has been eminently successful. This metropolitan district was charged with the responsibility of planning and financing the necessary development of a growing community and of furnishing adequate supplies to its constituent municipalities at fair and equitable rates. Each member municipality fixes the rates to be charged to its own consumers. The revenues of the district are raised from the sale of water at a rate so set that the income, as nearly as possible, equals the fixed and operating costs. The powers and functions of the corporation are executed and discharged by an administrative board consisting of representatives from the member municipalities; the city of Vancouver, which contains two-thirds of the population served by the district, has a majority vote. The undertakings of the corporation are under the management of a commission appointed by and subject to the authority of the board.

Approximately 10 years ago Victoria, B.C., and three neighboring municipalities formed the Greater Victoria Water Dist. to satisfy the requirements of 120,000 persons. Although not as large as the Greater Vancouver Water Dist., it has been very successful in its administration of water supply to the vicinity of Victoria.

Federated Metropolis

A federated metropolis is a compromise arrangement that permits a large metropolitan area with many incorporated suburbs to exercise unified direction of problems which are metropolitan in scope, while at the same time the constituent cities retain their separate identities and autonomously administer services which are local in nature. Cities comprising the federation transfer certain powers over matters regional in character to a central metropolitan government.

The Toronto, Ont., plan, based upon these principles, became effective on Jan. 1, 1954. It establishes a federation of thirteen cities, known as the "Municipality of Metropolitan Toronto," to serve 1,250,000 persons. The metropolitan council, which administers the metropolitan government, consists of twelve representatives of the city of Toronto and the same number of suburban representatives. Areawide functions, such as assessment, transit, and planning, are entrusted to the metropolitan municipality. The financing of metropolitan roads and arterial highways is shared equally by the metropolitan government and the province of Ontario. With respect to other functions, such as water supply and sewage disposal, there is a division of authority between the constituent cities and the metropolitan government. Local water distribution, sewage collection systems, local public works, police and fire protection, unemployment relief, local planning, streets that are not included in a metropolitan network, general administration, and administration of certain grants-in-aid from the Ontario government are left to the constituent cities. York County, in which Metropolitan Toronto lies, still provides certain services—with respect to roads and law enforcement, for instance—in some areas of the county.

As of Jan. 1, 1954, the metropolitan government acquired from the local municipalities, and became the owner of, all the assets (including all of the pumping and treatment plants and the wholesale distribution mains) used by the metropolitan government for metropolitan services. No compensation was paid to the local municipalities, but the metropolitan government assumed all of the outstanding bonds involved. The construction and maintenance of pumping stations, treatment plants, trunk mains, and reservoirs for the wholesale distribution of water to the thirteen cities constitute the water supply services of the Municipality of Metropolitan Toronto.

The metropolitan government is now responsible for the expansion and extension of the pumping facilities and the wholesale distribution mains so that water will be carried to the borders of all of the member municipalities, which will purchase it at wholesale and distribute it to consumers at a price to be determined by the local municipalities. The water supplied by the metropolitan government to the member municipalities at wholesale is to be furnished at cost.

Ontario will make an annual grant of $4.00 per capita to the metropolitan government in order to assist it in providing the metropolitan services deemed necessary. As the population of the area is approximately 1,250,000, the annual grant to be made in 1954 will be approximately $5,000,000.

Assuming that the units of government comprising a metropolitan area are willing to recognize their interdependence, a federated metropolis affords some very real advantages: the administration of unified areawide

functions by the metropolitan government, with the retention of a considerable amount of local autonomy by the constituent cities and the continued exercise of certain appropriate functions by the county; a broad tax base; and the consolidation or elimination of special districts.* Enabling legislation would be needed for this federated-metropolis approach to become available in many states.

City-County Consolidation

City-county consolidation affords a means whereby county functions may be assumed by a city to eliminate duplication of governmental services within a given area. This step has been taken in San Francisco, Calif., St. Louis, Mo., Denver, Colo., and Honolulu, T.H.; and, to a lesser degree, in New Orleans, La., Baltimore, New York, and Philadelphia.† It is not a very satisfactory approach to the problem because watershed and metropolitan areas do not conform to county or city boundaries and often embrace more than one county. For the same reason, the creation of certain city-county departments without city-county consolidation would not be very effectual. The twenty-third amendment to the constitution of the state of Washington provides for consolidation of a city and county with at least 300,000 people, but the state legislature must pass enabling legislation before consolidation can be carried out. The adoption of a sound county home rule charter to strengthen and streamline the administrative structure of county government may, in itself, be highly desirable, but it does not afford a solution to the metropolitan problem.

Voluntary Cooperation

Voluntary cooperation—through which, by contract, a county undertakes functions for its subsidiary units, a central city provides services to other cities and unincorporated areas, or two or more governmental units jointly own and operate facilities or jointly finance a program—is a stopgap measure and does not constitute a sound solution of the metropolitan problem.‡

* Baton Rouge, La., several small neighboring communities, and the parish (county) of East Baton Rouge have been operating under a form of federated government since 1949. Under this reorganization, the city of Baton Rouge was increased in area from 5½ to 35 sq miles, and in population from 30,000 to 106,000. Joint control under separate legislative direction of the city and county has resulted in eliminating duplication by unifying the administration of services. A number of the members of the Baton Rouge City Council and of the East Baton Rouge City-Parish Council are the same, and their legislative program is closely coordinated.

† Atlanta, Ga., has reshuffled services between city and county jurisdiction to provide for remote areas. On Jan. 1, 1952, Atlanta tripled its area from 35 to 118 sq miles and added 96,985 new citizens to its population of 331,314; it furnishes services outside of the city by contract.

‡ In California, a county service area law has been enacted to cope with the fringe area problem. County boards are authorized to create county service areas in unincorporated territory and to levy taxes to finance municipal type services, such as expanded police protection, structural fire protection, park and recreation facilities, and others. The law has no application to functions and services provided for the benefit of all county residents, such as welfare, hospitals, and fire protection for forest and grass lands. Under this law, a county service area may be established by a county board on its own initiative or upon a petition signed by not less than 10 per cent of the registered voters residing within the proposed area (*7*).

With a broader financial basis, money can be borrowed on more favorable terms, at lower interest rates. If utility revenue bonds are authorized by statute and utilized for metropolitan governmental utilities, and revenue is obtained on the basis of services rendered and of benefits accruing to those served, revenue-producing functions may be undertaken by a metropolitan government without being restricted by the constitutional and statutory debt limits and without interfering unduly with the existing tax structure.

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Metropolitan Water District of Southern California—*Robert B. Diemer*

A paper presented by Robert B. Diemer, Gen. Mgr. & Chief Engr., Metropolitan Water Dist. of Southern California, Los Angeles.

The Metropolitan Water Dist. of Southern California was organized under a general state law passed in 1927. Although the district encompasses the land areas of cities, municipal water districts, and one county water authority, it is, by the terms of the statute, a separate political corporate entity, not a federation of cities. The district was incorporated in 1928 under the procedure set out in the act, involving elections in the original member cities. Others have since joined. The statute does not require the areas composing the district to be contiguous, nor are they limited to only one county.

California courts have held that the district has the powers ordinarily attributable to a municipal corporation—that is, the power of eminent domain, of suing and being sued, of using a corporate seal, of acquiring and disposing of property, and so forth—but its activities are restricted to the production, transportation, and distribution of water, primarily for domestic and municipal use, although service for other uses is within the scope of its authority.

Management

The legislative and administrative functions of the district are vested in a board of directors, which can and does delegate considerable authority to staff officers. Members of the board are appointed by the chief executive officers of the units composing the district, with the consent and approval of the respective governing bodies. The directors are officers of the district, however, not of the several units, and hold office at the pleasure of the appointing power, without fixed terms. This system results in a desirable continuity of service. The directors serve without compensation but are entitled to expenses incurred in their work.

The board determines district policy on annexation of new territory, con-

struction of works, letting of contracts, assumption of indebtedness, issuance of bonds, and levying of taxes; in general, it controls the administration of the district's affairs and the building and operation of its works. As of May 1, 1954, the board consisted of 29 directors, representing the cities and constituent areas that comprise the district. Under the provisions of the Metropolitan Water District Act, each constituent unit is entitled to at least one director and an additional director for each $300,000,000 of assessed valuation.

Pursuant to its statutory authority to create offices and delegate powers to officers, the district has established, by ordinance, the office of "General Manager and Chief Engineer." He is the principal administrative officer for the district and is in charge of the business organization, as well as the engineering, construction, and operating work. He reports to the board at frequent intervals and makes such recommendations as appear to him to be proper in the general administration of district affairs. In many administrative functions, the general manager and chief engineer has complete authority. Matters of employment within his department are under his control.

The board has established additional offices whose incumbents report directly to it. These are the controller, the treasurer, and the general counsel. The controller and the treasurer are responsible for all district accounting and custody and disbursement of funds. The general counsel, as the chief law officer of the district, advises the board of directors and other district officers and handles the preparation of contracts, annexation, bond procedure, and litigation.

Revenue and Finance

The district, under statutory authority, sells water to its constituent units on a wholesale basis, at rates established by the board. The district also has authority to sell surplus water not needed within the district itself, on a contract basis, at rates established by the board and subject to periodic revision. In dealing with the federal government and with the state and its agencies, such contracts may be made for permanent service.

The district has general authority, within prescribed limits, to levy ad valorem taxes on real and personal property. The annual budgetary requirements and tax rate are determined by the board of directors. The machinery for collecting such taxes is handled by the several county organizations in counties in which the district operates. The district also has authority to levy special taxes upon areas annexed to it. There is no statutory formula for determining the amount of the special taxes, but, in practice, the policy of the board has been to require each annexed area to pay an amount equal to what would have been derived through tax levies had the area been a part of the district from the beginning. This amount, plus interest, may be paid in a lump sum but is customarily tendered over a 30-year period (together with accrued interest) in equal annual installments.

The district has statutory authority to incur indebtedness and issue bonds. The procedure for issuing bonds conforms with general municipal practice. The bonds are authorized at elections by majority vote and are placed on public sale, the interest rate ordinarily being fixed by the best bidder. The life of the bonds may extend over a

period of 50 years, with early maturities deferrable for 15 years. During the payment period the bonds are retired in substantially equal annual amounts. The board of directors also has authority to issue short-term bonds and thereby incur indebtedness for the purpose of meeting emergencies resulting from disaster. This authority is designed to avoid the necessity of carrying too large a reserve.

Major construction and purchase contracts are let to the lowest responsible bidder, as the result of public advertising. The district often performs work by force account as well.

Expansion of District

When the district was first organized in 1928, there were 11 cities within its boundaries. Today the number of cities has risen to 50. The area of the district has been increased from 624 to more than 1,970 sq miles, and its population has grown from 1,600,000 in 1928 to more than 4,000,000 in 1954. During this period its assessed valuation has increased from $2,200,000,000 to more than $6,000,000,000.

A number of areas that are not now in the district are actively considering annexation. These areas are located in Los Angeles, Orange, San Diego, San Bernardino, and Riverside counties. Their annexation would increase the district's assessed valuation by more than a billion dollars and would add about 1,000,000 to its present population.

The aqueduct system, including distribution facilities, is 457 miles in length. The aqueduct, designed to deliver 1,600 cfs of water from the Colorado River to the Southern California Coastal Plain, was completed in 1941. Initial construction included five pumping plants, each with three 200-cfs capacity pumps. The cost of the works up to 1941 was $20,000,000 less than the original estimates. The project was financed by a $220,000,000 bond issue authorized by the voters of the district by a decisive ratio of 5:1 in September 1931. The total cost of the project to date is $260,000,000.

The district is now engaged in extending the aqueduct system to meet increasing water needs within the district areas. A $52,000,000 construction program, started in 1952, includes enlargement of the delivery capacity of the main aqueduct by the addition of two 200-cfs pumps at each of the five existing pumping plants.

Even with all of this new construction work in progress, and with aqueduct bonds now in the process of being amortized, the tax rate of the district is being steadily reduced. The district tax rate reached a maximum of 50 cents per $100 of assessed valuation in 1946 and has been decreasing ever since. As of 1954 it is down to 25 cents per $100, making it probably the smallest item on most tax bills in the cities of the district.

This money is buying the property owners in the district a water supply to support and increase the value of all their holdings. The wholesale rates to members of the district are $10.00 per acre-foot for raw water and $20.00 per acre-foot for softened water.

All costs of the Metropolitan Water Dist. aqueduct are paid for by those who live within the district, and there is no federal government subsidy of any kind. District facilities are owned, controlled, and paid for by the people they serve.

Chicago Water System—*H. H. Gerstein*

A paper presented by H. H. Gerstein, Asst. Chief Water Engr., Bureau of Water, Dept. of Water & Sewers, Chicago.

This paper will discuss the problems in the management of the Chicago water system resulting from the legal requirement that obligates the system to furnish water at the city limits, in any quantity needed and at inside-city rates, to all incorporated suburban communities located in the Chicago Sanitary Dist. The city has made no attempt to shirk its legal obligations and has done everything in its power to provide reliable water service to its neighbors. Large capital expenditures have been made for the construction of ample-sized feeder mains to furnish sufficient water to the periphery of the distribution system for the increasing needs of the growing suburban communities.

Sanitary District Act

The Illinois Sanitary District Act of 1889, creating the Chicago Sanitary Dist., was passed for the purpose of eliminating a serious public health hazard caused by the excessive sewage pollution of the water supply obtained by Chicago from Lake Michigan. This condition had resulted in a high incidence of waterborne disease and created a critical problem for the fast growing city. In addition, the discharge of packinghouse and tannery wastes into the Chicago River caused a serious odor nuisance and contaminated the water supply with organic matter whenever the river flowed into the lake. The district constructed a drainage canal to divert the flow of the grossly polluted Chicago River from Lake Michigan and into the watersheds of the Des Plaines and Illinois rivers. Dilution water was diverted from Lake Michigan to oxidize the sewage and industrial wastes. Other sanitary projects in the program included the construction of: intercepting sewers, to handle wastes formerly discharging directly into the lake; extensions to the drainage canal, to cause the North Branch of the Chicago River and the Calumet River to flow away from the lake; and, later, sewage treatment works.

Paragraph 366, Section 26, of the Sanitary District Act of 1889 requires that any city, incorporated town, or village in the sanitary district that owns a water works system drawing from a lake made safe from pollution by the construction of facilities under the act must supply water at inside-city rates to any other city, town, village, or incorporated area in the sanitary district. The act was amended in 1951 to include townships and other municipal corporations as beneficiaries of the water supply privileges.

Extent of Service

In 1953 the Chicago water system supplied a population of 3,700,000 and an area of 213 sq miles in the city, as well as 51 incorporated suburban communities, in the sanitary district, with a population of 598,000 and a total area of 134 sq miles. The total population supplied was 4,298,000, and the total area 347 sq miles.

The sanitary district, at present, covers an area of 491 sq miles and has an estimated population of 4,700,000.

The Chicago system now supplies 92 per cent of its population and 70 per cent of its total area. In addition to Chicago, five communities in the district take their water supply direct from Lake Michigan: Evanston, Wilmette, Winnetka, Glencoe, and Kenilworth. Four other suburban communities are supplied with water from these works. One of these is also, at times, supplied from Chicago. As there are 77 incorporated areas, excluding Chicago, in the sanitary district, there remains a balance of 18 communities not now supplied with lake water which Chicago will be obliged to serve if requested. Applications for water service from three of these communities are now being processed.

A limited ground water supply available in the Chicago metropolitan area is used as a source by the suburban communities not now taking lake water. As the ground water is generally quite hard, it is believed that eventually most of these communities will demand lake water because of its better quality and because it is the only source available in the quantities needed by their growing population and industries.

A number of communities formerly located outside of the sanitary district have arranged to be annexed in order to obtain the benefit of the lake water supply from Chicago at low rates. The sanitary district may come to include all of 954-sq mile Cook County.

Of the 51 suburban communities now obtaining Chicago water, 40 are supplied directly from the Chicago water system and 11 indirectly, through communities supplied by Chicago. In 1953 the average pumpage of the Chicago water system was 1,007 mgd, of which 88 mgd, or 8.8 per cent of the total, was supplied to suburban communities. The average usage by suburban consumers, including industrial consumption, was 147 gpcd.

Conditions of Service

The metered water rate to consumers within Chicago is a flat 12 cents per 1,000 gal, which is also the rate charged to all of the incorporated suburban communities in the sanitary district. Private consumers and industries located in unincorporated areas outside the city limits are charged a rate 50 per cent higher, or 18 cents per 1,000 gal. In 1953 Chicago tried to get the Illinois legislature to amend the Sanitary District Act to permit an outside-city rate increase of 30 per cent, but the effort was unsuccessful because of the strong suburban opposition, although the suburbs that buy water from Chicago and then resell it to other communities within the district charge rates ranging from almost double the Chicago rate to considerably higher.

The obligation of Chicago to furnish water to the suburbs proves to be a one-way responsibility. For example, Chicago went to considerable expense to provide feeder main capacity to the city limits in order to supply the needs of a certain suburb within the sanitary district which requested service. This community later found it to its advantage to buy the major portion of its water from another system and reduced to a small amount the water taken from the Chicago system. When high water demands occurred during the summer of 1953, the community discovered that the other supply was insufficient for its needs and again started to take water in large

amounts from its connection to the Chicago system. This happened at a time when the Chicago system was having difficulty in furnishing the requirements of its regular customers. Unfortunately Chicago has no demand charge in its rate schedule at present.

Chicago has endeavored to induce the suburbs applying for water service to include sound engineering principles in the design of water works facilities to serve their present and future needs. Incorporated in the contracts for water supply are requirements for ample storage facilities and sanitary precautions. There has been, in general, a healthy cooperative relationship between the water departments of the city and the suburbs, with the result that the suburbs have benefited from the expert advice of the city's water works engineers.

In the past there has been little complaint from the suburbs regarding the adequacy of the supply obtained from the Chicago system. During the record hot-weather period in 1953, however, a number of communities complained of insufficient supply, owing to the very high usage of water for lawn sprinkling. Most of these communities have grown at an unprecedented rate, and their water requirements are exceeding the amounts originally contracted for. Their supply difficulties can often be attributed to the inadequate carrying capacity of the mains from the Chicago city limits to their reservoirs, or to insufficient storage capacity, rather than to insufficient supply at the city limits from the Chicago system.

Chicago is now embarking upon a 5-year water works capital improvement plan, at a total cost of $125,342,000. This program includes construction of an additional filtration plant, feeder mains, supply tunnels, a reservoir, and pumping station facilities that will improve the water quality, increase the capacity and reliability of the system, and also result in an enlarged supply and greater pressures at the city limits.

Conclusion

The Chicago water works management believes that the suburbs in the sanitary district are desirable customers and that the Chicago system, with its developed facilities and technical skill, can furnish better and more reliable water service at a lower cost to the suburbs than can be obtained from any other source. It is felt, however, that the legal limitation on water rates is not realistic and provides inadequate compensation for the cost of the extra water works facilities that Chicago must build in order to provide the suburbs with good service. Experience has shown that the legal requirement to provide service at the city limits in the quantity requested by, and at the convenience of, the suburbs, makes it difficult to carry out sound engineering planning for the most economical means of furnishing water supply to such areas.

Washington Suburban Sanitary District—*Harry B. Shaw*

A paper presented by Harry B. Shaw, Chief Engr., Washington Suburban San. Com., Hyattsville, Md.

By 1910 suburban communities had developed in Maryland along the transportation lines leading out of Washington, D.C., to an extent that caused civic-minded local residents and some of the authorities of the District of Columbia to be concerned over the resulting pollution problems. As a consequence of the activities of these and other Maryland residents, the Maryland General Assembly, in 1918, created the Washington Suburban Sanitary Commission, with jurisdiction over an area of 95 sq miles in Maryland surrounding the District of Columbia. This area lies within two counties, Montgomery and Prince Georges, which are separate political jurisdictions. A large section of the Washington suburban portion of Montgomery County drains into Prince Georges County.

As previously mentioned, the development of the suburban area had been principally along the railroad and trolley lines leading to the city. The latter usually followed old highways, which, in turn, generally followed the high ground so as to have good drainage. Communities were therefore commonly located on ridges and, hence, away from watercourses. One exception was in the area traversed by the tidal Anacostia River, where, at the head of tidewater, the town of Bladensburg and adjacent communities had been established, the former in colonial days. Neighboring communities, however, were built on higher ground, with undeveloped lands in between, in the valley beds proper.

The sanitary problem was not limited to sewage disposal. Water supplies were generally from wells, mostly shallow. Some of the towns and several private real estate developments had water supplies, all except one of which came from underground sources. Privies and cesspools predominated as means of sewage disposal, although there were a few sewerage systems and so-called sewage treatment plants. Water supply was, therefore, also a problem, because of the sewage disposal methods used in the area, as well as the lack of developed supplies.

Disposal of surface water was generally on the ground, although a few communities had combined-flow sewerage systems. Refuse was hauled by private collectors to dumps or farms, or was buried, composted, or burned by householders.

The population of the sanitary district at its inception was 32,000, and the assessed valuation of the property within its boundaries was $20,000,000. The organic law creating the district broadly provided, among other things, that:

1. The commission be composed of three members, one appointed by the governor and one by each board of county commissioners subject to the approval of the State Board of Health
2. The commission have the exclusive right to employ and discharge personnel
3. The commission have the right of eminent domain
4. All properties, except those used for agricultural purposes, abutting a

water main or sewer built or acquired by the commission be assessed a front-foot benefit charge to defray the cost thereof

5. The commission have the duty (and this was made mandatory on the county governments) to levy an ad valorem tax to make up any deficiency in revenues resulting from failure of the front-foot benefit charges to meet the requirements of the bond issues for water main and sewer construction

6. The maintenance and operation of the water and sewerage systems be paid for out of a water consumption charge and a service charge.

7. Bond issues be limited to 14 per cent of the assessable value of the property within the sanitary district, but need no authorization other than the pro forma approval of the public service commission. (The two boards of county commissioners were required to sign the commission's bonds, thus securing them by the full faith and credit of their respective counties.)

Financing

To some extent, it has been necessary to change the basic financial concepts laid down in the organic law creating the commission. Following World War I, although the suburbs of Washington started to grow rather rapidly, the commission's basic task was to correct the sanitary problems in the existing communities. The commission began by developing unimpounded surface supplies on several of the nearby streams, constructing intakes above the major sources of pollution, erecting several temporary, small rapid sand filtration plants, and extending lateral mains in the communities that did not have public water systems. The commission acquired the local water systems and put them in good operating condition, assuming their outstanding debts and reimbursing the communities for their equities therein. It is to be noted that, once the commission acquired these systems, the properties abutting them were immediately subject to front-foot benefit charges.

The assessed valuation of the area did not permit the commission to install trunk sewers up the valleys between the communities or to construct sewage disposal plants. It therefore confined its early operations to providing lateral sewers in the communities that did not have them, putting the existing sewerage systems into satisfactory operating condition, and extending the sewer outfalls from the communities on higher lands down the slopes of the valleys to the nearest major watercourses. Nothing was done in the early days to solve the storm drainage or refuse collection and disposal difficulties of the area, as these did not then present a serious problem.

In the succeeding years Washington continued to grow in importance, and, as a result, the suburban growth around the city also continued, even during the depression of the 1930's. The temporary surface water supplies installed by the commission and the underground supplies of existing systems were gradually abandoned and superseded at various intervals by permanent impoundments of more remote streams and the construction of permanent filtration plants, with the necessary larger water supply lines from the more remote stream sources to the distribution system in the suburban area. These expenditures were of considerable magnitude and had to be financed out of special bond issues

authorized by the legislature and amortized out of water receipts.

The water supplies of the scattered communities were gradually connected. Increasing construction costs and the installation of the feeder mains to connect the various communities in order to permit the elimination of the numerous temporary supply sources brought about a gradual rise in front-foot benefit charges, but not to a point where these became burdensome. It is to be noted that, although the feeder mains were relatively expensive, the growth of the community was such that, because of the gradual development of the intervening areas, considerable front-foot benefit charges were obtained from the properties abutting the feeders.

TABLE 1

Schedule of Charges

Class	Water	Sewer
Annual Front-Foot Benefit Charge—¢/ft		
Business		
First 200 ft	33	33
Excess	25	25
Subdivision		
First 150 ft	25	25
Excess	13	13
Small acreage		
First 150 ft	25	25
Second 150 ft	13	13
Excess	7	7
Ad Valorem Tax per Assessed Valuation—¢/$100		
General water and sewer construction		6
Storm drainage		4
Total		10
House Connection Charges—$		
¾-in. water connection		
Outside meter setting		115
Inside meter setting		105
4- or 6-in. sewer connection		175
Other Charges		
Water use—¢/*1,000 gal*		27
Sewer use—¢/*1,000 gal water*		14
Refuse collection and disposal (single-family unit)—$/*month*		2.25

Development of the trunk sewerage system was not very extensive for financial reasons until the latter part of the 1930–40 decade. At that time the watercourses in the area were becoming extensively polluted, and trunk sewer construction was gradually accelerated. In several of the main valleys, the trunk sewers were connected to their counterpart in the District of Columbia at the district boundary line. A primary sewage treatment plant was constructed in the Anacostia Valley, below Bladensburg. As the development of the trunk sewerage system was gradual, at first it was possible to defray its costs out of front-foot benefit charges and the ad valorem tax. The volume of trunk sewer construction finally became so great, however, that it was necessary to devise some other method of financing it. As a result, the Maryland legislature, in 1951, enacted a law permitting the commission to institute a sewer usage charge—based upon water consumption—against properties connected to the sewerage system, to defray the cost of future trunk sewer construction, the maintenance of the sewerage system, and sewage disposal, including payments to be made to the District of Columbia. Under an agreement about to be concluded, all the sewage of the sanitary district will be discharged into the sewers of the District of Columbia and conveyed by the latter's sewerage

system, or augmentations thereof, to the District of Columbia disposal plant on the Potomac River at Blue Plains, where it will eventually be given complete treatment.

The storm drainage problem due to the development of the area began to become serious in the early 1940's, and the commission has since then been authorized by successive legislatures to issue bonds for the construction of storm sewers. Such projects are approved by the commission after public hearings and are built from time to time, within the limits of legislative authorization. The cost of retiring these bonds is paid for out of the ad valorem tax, as is the cost of maintaining the storm drainage system.

The refuse collection and disposal problem also became increasingly acute in the late 1930's and early 1940's. As a result, the commission has constructed two incinerators and operated several sanitary landfills in both Prince Georges and Montgomery counties. Incinerator construction is financed out of several special bond issues authorized by the legislature and paid for out of refuse collection and disposal charges, which likewise cover the cost of maintaining that service.

There are also miscellaneous charges which obtain in the sanitary district. The commission installs house connections from the street mains to the abutting property lines. For this service, the commission collects a uniform cash charge throughout the sanitary district, based upon the size of connection. The commission has jursidiction over plumbing and gas-fitting installations within the sanitary district and collects permit fees for inspecting such work. In addition, the commission has jurisdiction over the installation of all utilities in the area and issues permits therefor at a fee. A schedule of the principal charges made by the commission is given in Table 1.

Extent of Operations

The sanitary district has a present assessed valuation of approximately a billion dollars. Its net outstanding indebtedness is approximately $75,000,000. It has 1,142 miles of water mains, 969 miles of sewers, 84,777 water house connections, and 76,660 sewer house connections. The average consumption in 1953 was 31 mgd. The area of the sanitary district is 212 sq miles, and the estimated population served is about 425,000.

Progress in Weather Control

By Irving P. Krick

A paper presented on May 25, 1954, at the Annual Conference, Seattle, Wash., by Irving P. Krick, Pres., Water Resources Development Corp., Denver, Colo.

IN recent years, man has turned to the sea and to the air in his search for additional water resources with which to sustain life. In spite of vast irrigation and water storage projects, it has been increasingly difficult for nature to replenish dwindling water supplies through normal rainfall. This trend is accentuated during dry cycles in the weather, bringing into sharp outline the vital importance of seeking new sources of water if agriculture, commerce, and industry are to move forward at the accelerated pace characteristic of modern times.

The rapid development of methods to tap the never ending supply of moisture in the atmosphere offers a means of increasing water resources in areas of the world where rainfall regimes have been sufficient in the past to sustain life in its modern form but may be unable to meet present or future requirements. Great masses of water are carried on the air currents that continually circumnavigate the globe. For the most part, the areas with the greatest potential lie in the temperate latitudes and are characterized by relatively frequent storms. Additional moisture is taken from moving clouds within rain belts as they pass overhead, through a process that has become known as "cloud seeding."

There is no way of increasing moisture from the sky when nature is unyielding. Only during the occurrence of active natural storms can such operations be successful. The process, therefore, is one which does not disturb the normal rhythms in nature or the mechanisms which produce natural precipitation. Thus, neither the times at which storms occur nor their duration will be influenced. In essence, cloud seeding merely increases the rate of fallout of water from a storm over the area where additional water is desired. For example, if a storm is yielding 0.2 in. of rainfall per hour and, through cloud seeding, this rate can be increased to 0.3 in. per hour, the result will be to augment the water reaching the earth's surface by 50 per cent. If the storm continues for 5 hr, 1.5 in. of rain will fall instead of the 1 in. that would have been produced naturally. It is emphasized that cloud seeding is accomplished in a way that does not affect the potential of the storm to replenish itself with moisture and produce natural rainfall as it moves on to other areas.

Such operations imply that nature's rain-producing mechanisms are relatively inefficient. In truth, nature very seldom releases more than 5 per cent of the water passing overhead in storm winds. Thus, the augmentation by 50 per cent is accomplished if man can increase the fallout to 7½ per cent.

This process does not upset the hydrologic cycle, nor does it permanently remove water from the atmosphere. It merely increases the efficiency of the endless cycle of evaporation, transpiration, precipitation, and runoff. In areas where cloud-seeding operations are carried on consistently for long periods, equilibrium in the hydrologic cycle is raised to a higher point in the precipitation regime. In an area where 10 in. of rainfall has been normal, it might be increased to 15 in., with a resulting increase in water supply, vegetation, and other resources dependent upon water.

Early Efforts

Cloud seeding in the modern sense began in the latter part of the nineteenth century. Patents were held in the United States and in Europe on devices that would distribute dry-ice pellets into cloud formations. This implies that the inventors suspected the role ice crystals would perform in developing precipitation if produced within clouds by some artificial process. On the other hand, these early experimenters were unfamiliar with atmospheric behavior and were unable to obtain current soundings from the upper air with which to assess properly the potential of the weather to respond to their efforts. These early attempts failed owing to a lack of knowledge of the atmosphere. Furthermore, support for continued experimentation was withdrawn because the operators did not carefully record and assess the results of their work.

In 1946 Irving Langmuir and Vincent Schaefer of the General Electric Research Labs. successfully induced snowfall from a cloud of supercooled droplets by dispersing dry ice within the cloud from an aircraft. This set off a new and ever expanding series of experiments on weather modification throughout the world, including many in the United States. These experiments were aimed at learning whether and how much man could augment natural rainfall. Scientists in two categories, both having the same objective but attacking the problem in different ways, undertook this task. The first group carried on a set of scientifically controlled laboratory experiments, small in scope, aimed at obtaining a better understanding of cloud physics and precipitation mechanisms. The second group, composed of a few practicing meteorologists, launched a line of experimentation in which the known behavior of the atmosphere was utilized to lift cloud seeding from a laboratory exercise to a broad-scale commercial operation. Both groups have obtained information on the possibility of modifying weather, but only the second has been able to provide answers to the all-important question: by how much?

To assess the value of cloud-seeding operations, one must be in a position to detect precipitation increases resulting from them. This is made difficult by the variability in natural rainfall patterns, not only at a single location from storm to storm, but also from place to place within an individual storm (*1, 2*). Time tends to smooth out these variations with respect to both area and time. Thus, it became apparent that continuous operations in a specific area for a period of years would be required to permit the detection of the precipitation differences between the target and outside, unaffected, areas. This requirement effectively eliminates the possibility of

detecting amounts of rainfall increase from intermittent, small-scale, controlled experiments.

The public has not been able to distinguish between the two types of experimentation and has frequently been confused by conflicting claims. The researchers have contended that their results have been inconclusive from the standpoint of the economics of cloud seeding; commercial operators, on the other hand, have reported substantial successes, based upon an analysis of hundreds of thousands of hours of field operation in every climatic regime in the world.

Detection of Precipitation Increases

Inasmuch as the assessment of the technical and economic aspects of cloud seeding is the keynote to its future development and expansion, a tremendous effort has been expended in the development of statistical tests of sufficient sensitivity to produce conclusive evidence of cloud-seeding effects. Methodology has been evolved over the past four years by all agencies concerned with the problem. These include government and private research groups, commercial operators, and private and state institutions of higher learning charged with the independent evaluation of cloud-seeding operations. All investigators have recognized finally that a large sample of data is necessary to demonstrate cloud-seeding efficiency conclusively. It has, therefore, been necessary to turn to the long record of sustained, large-scale operations, primarily in the commercial field, to further this work.

Small-scale experiments may involve a mere 40–50 hr of operation during the course of a year, with no attempt to concentrate effects on a particular area, whereas a commercial operator, working in a specific project area, may accumulate many thousands of hours of operation during a similar period. In small-scale experiments, many storms pass that are not seeded, especially those which are of high intensity and defy proper control within the framework of the operational plan. Other storms may be seeded for only a small portion of the period of their duration. A commercial operator, however, seeds major storms, as well as those of less intensity, continuously during the entire period of active rainfall, in his effort to build up a cumulative increase in the rainfall over his target area during the life of the project. A specific percentage increase in the natural rainfall from an intense storm will obviously represent more water than a similar percentage increase in a minor storm. For example, in an area where natural rainfall may reach 20 in. in a year, the commercial operator will increase that to 30 in. if he is able to achieve a 50 per cent increase through cloud seeding. In a similar area, the research experimentalist, seeding sporadically over the year, may have influenced only 1 in. of the total 20 in. Even though he also may have augmented the sample of rainfall he worked by 50 per cent, this 0.5 in. must be detected within the recorded annual rainfall of 20.5 in. In comparison, the 10 in. of rainfall from sustained operations by the commercial operator represents one-third of the total recorded and is therefore more easily found.

To date no statistical methods sufficiently sensitive to detect the small contributions to natural rainfall produced by the researchers have been reported. On the other hand, it is pos-

sible to determine rainfall increases resulting from cloud-seeding operations designed to make a project area a continuous target for long periods. This is true because the difference in the rainfall experience between the target and unaffected outside areas becomes greater than the time-area variabilities in natural rainfall during the operational period. A method capable of yielding statistically significant results, described in an earlier paper (*3*), relies upon the development of multiple correlations between rainfall experience in the operational area and unaffected outside regions for periods prior to the advent of cloud seeding. These correlations can be made for various periods of time, such as a month or a year. Usually, the longer the period, the smaller the variability exhibited by the correlations.

This method has been adapted, with considerable success, to the evaluation of American projects that have been operated for periods of several years. It has also been extended to the establishment of relationships between rainfall experience in outside or control areas and runoff in drainage basins where cloud-seeding operations to increase stream flow are in progress. Relationships of 0.8–0.9:1 between control and target areas before the advent of cloud seeding are not uncommon. In these instances, the scatter of points about the curve of best fit (regression line) is of the order of 10–20 per cent. Such a relationship provides a means of detecting rainfall increases of the order of 30–40 per cent within acceptable limits of statistical significance. Thus, after cloud seeding has begun, a series of new points lying some distance outside the scatter of the old points will be established. If these points depart from the original regression line by a distance of more than twice the standard error, they represent statistically significant results. Following a series of operational years, a new curve can be constructed which will lie more than two standard errors from the original correlation. This curve will establish a new relationship between target and control areas, engendered by sustained cloud-seeding operations.

Two examples will be given to illustrate the use of this technique in assessing the results of cloud seeding. One involves a 3-year winter operation to increase the water content of snow in the Colorado Rockies in an effort to augment water supply for Denver, Colo. The evaluation uses a multiple correlation between the snow water content in the target and that in an outside area, unaffected by the operation. A second example deals with operations in Spain to increase stream flow for hydroelectric power generation. In this instance, a correlation between rainfall at a number of points outside the target and stream flow in the target area is developed.

Denver Operation

More than 60 per cent of Denver's total annual water supply is derived from winter snow in the Upper South Platte River Basin in the Colorado Rockies. The snow accumulated in the winter months melts in the spring to provide runoff into the city's storage reservoirs. The snow water content on Mar. 1 at various snowcourses in the Upper South Platte Basin reflects the accumulation of snow during the preceding winter months. Table 1 shows official snowcourse data since 1937 for each of the courses in this

river basin with a record of 10 years or more. The values from the beginning of the record through Mar. 1, 1950, reflect conditions before cloud-seeding operations began. Data for the years 1951–53 reflect conditions during cloud seeding. In each of the latter years sustained cloud-seeding operations were conducted on every suitable storm from Nov. 1 of the previous year through the succeeding 4 months. Thus, the snow water content reported on Mar. 1 reflects a 4 months' operation to increase snowpack in each year.

A glance at these data will show that the average snow water content for all upper South Platte Basin snowcourses was higher in 1951, 1952, and 1953 than in any previous year of record. There are only three chances in a thousand that such a distribution would occur accidentally. To lend support to the conclusion that cloud seeding added materially to snow water content, a study was made to relate the snow water content in the Upper South Platte Basin to that of some other watershed sufficiently far removed to insure the absence of cloud-seeding effects.

The Upper Yellowstone River Basin was selected for the establishment of such a relationship. Table 2 gives snowcourse data for the same period of record for the Upper Yellowstone Basin as that shown in Table 1 for the Upper South Platte Basin. Figure 1 shows the location of all snowcourses used in this study and the relative position of the two drainage basins. Figure 2 illustrates the correlation between the snow water content of the two river basins up to 1950, the period

TABLE 1

South Platte Basin Snow Water Content (Mar. 1)

Year	Chambers Lake	Big South	East Portal	Hoosier Pass	Fairplay	Wild Basin	University Camp	Loveland Pass	Lake Irene	Hour Glass	Jefferson Creek	Hidden Valley	Avg
	Snow Water Content—*in.*												
1937	3.4		0.7	4.8		7.6							4.1
1938	5.9	1.7	3.2	8.0	trace	9.1	16.3	11.3	20.7	5.2			8.1
1939	5.0	1.0	3.5	11.3	0.6	9.1	19.1	12.9	18.2	6.1			8.7
1940	5.6	2.7	2.8	5.7	0	6.9	14.4	8.3	14.8	5.0	5.6		6.5
1941	4.1	1.3	2.8	5.1	2.0	4.9	7.4	6.7	11.4	2.5	3.8	5.5	4.7
1942	4.9	1.4	2.4	9.2	1.2	10.9	13.8	7.7	13.4	5.7	6.4	7.6	7.1
1943	8.3	2.5	3.4	11.7	0	15.5	22.8	13.2	21.1		7.4	12.2	10.7
1944	2.3	0.7	1.2	3.9	trace	4.8	6.1	5.3	6.8	1.7	3.2	4.4	3.4
1945	7.5	3.4	4.5	5.2	0.5	9.5	16.0	10.2	15.8	7.5	4.2	8.4	7.7
1946	5.8	1.6	1.8	8.9	trace	8.9	20.2	12.3	17.7	5.4	7.4	6.6	8.1
1947	6.0	2.1	6.8	7.3	1.6	11.3	19.3	12.6	13.4		8.6	10.3	9.0
1948	8.0	3.3	5.1	9.2	3.0	11.1	15.5	9.9	19.5	6.6	7.2	10.3	9.1
1949	9.2	2.9	2.3	9.3	2.2	15.5	20.2	11.6	26.1	9.2	7.1	12.5	10.7
1950	5.4	2.0	5.3	7.1	1.0	11.0	18.6	7.9	17.0	5.3	4.3	8.6	7.0
1951	10.3	3.1	6.0	14.1	1.8	18.2	26.2	17.7	25.3	8.9	11.9	12.6	13.0
1952	9.2	1.8	5.6	15.5	2.3	19.1	22.0	21.0	26.5	8.4	11.7	13.6	13.1
1953			3.6	10.3	2.8	10.8	20.2	15.7	18.4			8.1	11.3

prior to cloud seeding. A line of best fit is drawn through the points for 1937–50, for which there is a correlation coefficient of 0.76. Although fairly high, this correlation does not eliminate considerable scatter in the points arranged about the regression line. In spite of this scatter, however, it will be noted that the points for 1951–53 lie far outside the general clustering of points for unseeded years.

tent of 7.8 in. in the Upper South Platte, whereas it was actually 13.0 in. Similarly, in 1952 the anticipated snow water content in the target area was 9.9 in. and the actual value was 13.1 in. In 1953 these figures were, respectively, 8.1 in. and 11.3 in. As already stated, the points for 1951–53 are all very much higher than those of preceding years. Indeed, when this precipitation population is treated

TABLE 2

Upper Yellowstone Basin Snow Water Content (Mar. 1)

Year	Hells Canyon	Independence	Crevice	Cooke City	Camp Senia	Lake Camp	Lupine Creek	Avg
	Snow Water Content—*in.*							
1937				6.2	3.9	7.1		5.7
1938				7.0	3.0	10.6	7.5	7.0
1939			8.6	7.0	4.0	7.3	7.1	6.8
1940			7.4	5.5	2.3	8.5	5.3	5.8
1941		6.6	5.1	3.4	1.7	5.6	4.6	4.5
1942		11.5	5.5	5.2	5.8	6.6	6.0	6.8
1943		24.3	14.2	12.8	9.5	18.0	16.0	15.8
1944		9.7	4.6	2.1	5.8	6.1		5.7
1945		9.7	5.9	3.8		6.7	3.9	6.0
1946	12.6	9.7	7.7	6.4	4.7	8.5	9.3	8.4
1947	14.4		8.8	7.2	6.2	9.5	8.0	9.0
1948	10.6	18.6	11.2	8.2	9.3		7.8	10.9
1949	13.4	20.3	11.4	9.3	6.6	12.5	13.3	12.4
1950	14.1	14.2	7.5	5.8		10.1	9.2	10.1
1951	14.0		7.1	7.7		8.8	7.1	8.9
1952	16.3		11.7	9.3		12.8	13.7	12.8
1953	13.9		7.9	8.5		8.8	8.7	9.6

An examination of the chart shows that the snow water content of the Upper South Platte was far greater in these years than would have been anticipated from the relationship established for the record prior to cloud seeding. For example, in 1951, for the value of 8.9 in. recorded in the Upper Yellowstone, one would have anticipated, within the limits of error of the calculations, a snow water con-

realistically as a body of nonnormal data, all three cloud-seeded points lie outside the irregular area that forms the 5 per cent significance limit.

Statistical significance is thus established. Therefore, it is reasonable to attribute the increased snowpack reflected by this displacement to cloud-seeding operations. As the work continues, additional points will be plotted, and, if their displacement

from the original curve remains similar, a new relationship will be established between control and target area precipitation as a result of cloud seeding. If a new curve constructed from

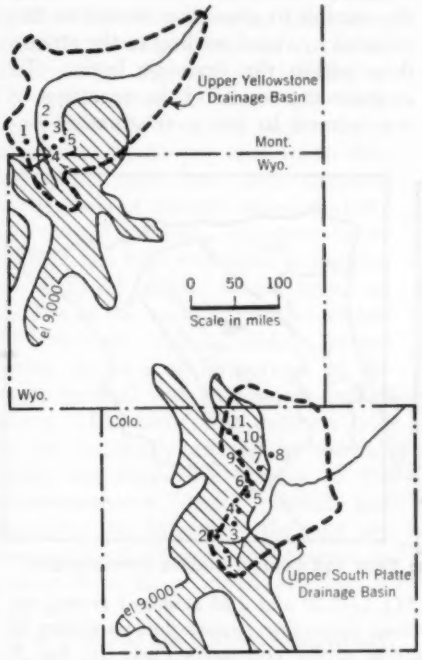

Fig. 1. Upper Yellowstone and South Platte Basin Snowcourses

Upper Yellowstone: 1—Crevice, 2—Hells Canyon, 3—Independence, 4—Cooke City, 5—Camp Senia; South Platte: 1—Fairplay, 2—Hoosier Pass, 3—Jefferson Creek, 4—Loveland Pass, 5—East Portal, 6—University Camp, 7—Wild Basin, 8—Hidden Valley, 9—Lake Irene, 10—Chambers Lake, 11—Big South.

these points lies more than two standard errors from the original curve, it will reflect substantial and consistent benefits from cloud seeding.

It is this type of evidence which, as it accumulates, will confirm the effectiveness of cloud seeding in increasing water resources. In the preceding illustration, the scatter of points about the original correlation curve requires approximately a 50 per cent increase in South Platte snow water content for the points to depart more than two standard errors from the regression curve. Had the correlation been higher and the scatter less, a smaller percentage increase would have yielded

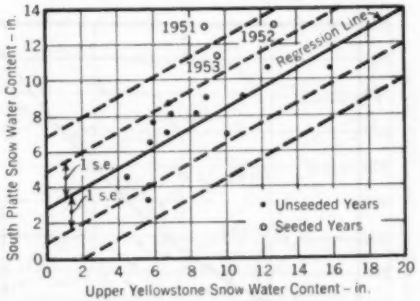

Fig. 2. Control and Target Snow Water Relationship

The snow water content of the control basin (Upper Yellowstone) was plotted against that of the target basin (South Platte) as of the same date (Mar. 1). The correlation coefficient was 0.76. In terms of standard error (s.e.), the departure of the seeded-year points (1951–53) from the regression line was respectively, 2.76, 1.72, and 1.72; the corresponding probabilities were 0.006, 0.85, and 0.85.

results of similar statistical significance. Thus, the establishment of the highest possible correlation between target and control area is desirable in order to detect small increases in precipitation within limits of statistical significance. Furthermore, the closer this relationship, the shorter will be the series of data required for conclusive evidence. For this reason, great effort is being made to perfect these correlation techniques.

It is a simple matter to assess the economic benefits of cloud seeding, once evidence of the type illustrated has been obtained. For example, at Denver, a 50 per cent increase in snowpack from cloud seeding will be responsible for more than 20 per cent of the city's total annual supply. It has been found that the value of this water far exceeds the cost of operations and, therefore, justifies a continuation of the work as long as the need for additional water supplies exists.

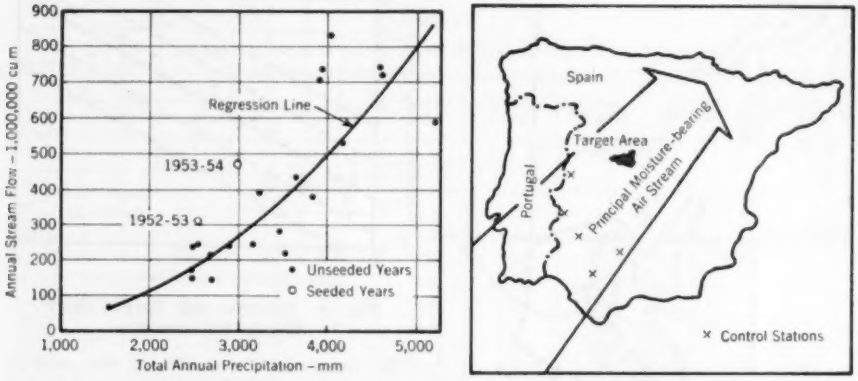

Fig. 3. Relationship of Target Area Stream Flow and Control Station Precipitation

The seeded-year points (1952–53 and 1953–54) lie 2.89 and 2.15 standard errors, respectively, from the regression curve, reflecting respective stream flow increases of 68 and 74 (estimated) per cent. The equation of the regression curve is: log A $= 1.0234 + 2.131$ *log* P; *in which* A *is stream flow and* P *is precipitation.*

Spanish Operation

On Oct. 1, 1952, cloud-seeding operations were started in the Rio Alberche drainage basin in central Spain. This undertaking was supported by Union Electrica Madrileña, a power company supplying a portion of the electrical energy consumed by Madrid. The 1952–53 water year extended from Oct. 1 to Sep. 30. The bulk of the precipitation producing runoff occurs between November and May.

Prior to the inception of this operation, technical experts of the client company completed studies relating the rainfall in areas that would be unaffected by cloud seeding to the stream flow within the drainage basin. To evaluate the results of the operation, it was agreed to use a relationship between the sum of the annual (October–September) rainfall at five outside-basin control stations and the runoff during each water year into the reservoir at Burquillo on the Rio Alberche. Rainfall data were taken from the official reports of the Spanish National Weather Service and runoff from the records of the company. For each year of record prior to the start of cloud seeding, rainfall–stream flow points were plotted and the curve of best fit was drawn. As was to be ex-

pected, the curve rose sharply with increasing rainfall.

Figure 3 presents an assessment of this operation to date, based upon the relationships used for the evaluation. It will be seen that the point representing the 1952–53 water year lies a considerable distance above the curve established by the original calculation. The water attributable to cloud seeding, within the limits of error of this calculation, is 68 per cent more than that which could have been expected on the basis of rainfall reported at the five control stations. A conservative estimate has been employed in plotting the 1953–54 point, based upon an analysis of the operation from October 1953 through March 1954, a period during which a good portion of the yearly rainfall and subsequent runoff occurs. Therefore, this estimate will not be materially altered by rainfall during the remaining portion of the water year. (Normal rainfall and runoff for the balance of the year are assumed.) A 74 per cent increase in stream flow from cloud seeding is indicated.

The 1952–53 and 1953–54 points are at distances greater than two standard errors from the original curve. Thus, a statistically significant achievement has been established. If the operation continues for a number of years with the same degree of success, subsequent points will continue to arrange themselves well above the curve. In due course, a new curve, widely separated from the old, can be constructed, reflecting the new control-target relationships resulting from sustained cloud-seeding operations.

Projects developed upon this basis tend to stabilize commercial cloud-seeding operations because the evaluation method, which is predetermined, can serve as a basis of payment. This procedure was followed in the Rio Alberche operation. In support of the results previously outlined, Fig. 4 depicts the rainfall pattern over the Iberian Peninsula during the first 15 months of operations—Oct. 1, 1952, through Dec. 31, 1953—expressed as a percentage of normal rainfall during this interval, based on official weather

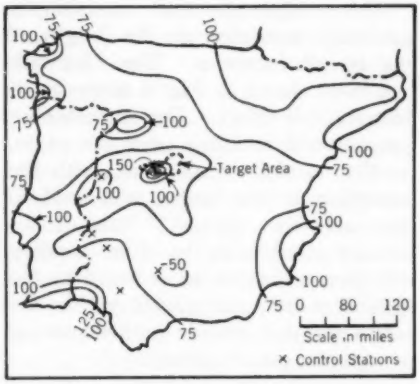

Fig. 4. Rainfall in Iberian Peninsula

The numbers on the isohyetal lines indicate the rainfall in the first 15 months of cloud-seeding operations (October 1952–December 1953), expressed as percentages of the preceding 30-year normal values. The highest percentages are found within the target area.

records for 30 years prior to cloud seeding. Throughout this entire period the interior areas of Spain and Portugal suffered severe drought. The rainfall in the target area at one point attained a value of 156 per cent of normal precipitation, in contrast to much lower values elsewhere in Spain and Portugal, including coastal areas. Of particular interest is the fact that pre-

cipitation in the control areas used for evaluating the results was, in general, well below 100 per cent. During the course of the operations, individual months exhibited patterns in which the rainfall was higher in the coastal areas of Spain and Portugal than over the target. In most months, however, the target received far greater amounts of precipitation than either the coastal areas or the surrounding interior regions of Spain.

The month-to-month variabilities gradually smoothen as the length of the record increases. The 15-month summary shown in Fig. 4 serves to illustrate this effect. The smoothening process will continue over the years, so that rainfall in all areas, with the exception of the target, will tend to approach the normal. Rainfall increases attributable to cloud seeding will then ultimately be reflected by the difference between rainfall within the target and that outside, both expressed as percentages of normal.

Results to Date

The author's organization, during the past 5 years, has completed approximately 250,000 hr of broad-scale cloud-seeding operations in eighteen states and six foreign countries. An assessment of results is contained in approximately 195 reports covering these operations, in the files of the American Institute of Aerological Research. The results for various seasons of the year in different parts of the world are summarized in Table 3.

Technical Considerations

The elementary concepts involved in cloud seeding to increase precipitation have been reviewed in a previous paper (*4*). Therefore, the discussion of these principles in this article will be limited to a statement of the essentials. A large proportion of the rainfall in the temperate latitudes occurs along zones of interaction between cold polar air streams and warm tropical or subtropical ones. Atmospheric disturbances distort these zones into wavelike configurations, marked by falling atmospheric pressure at the crest. These become the migratory cyclones of the middle latitudes, sometimes referred to as low-pressure areas on weather maps. The warm air stream passes over the cold air stream on the east side of the cyclone. On the west side, the cold polar air underruns the warm current, forcing it aloft. The rising motions in the warm air stream along these two zones of interaction are responsible for the development of the major cloud and rainfall belts, and, thus, for most of the precipitation recorded in the middle latitudes.

It has been found that, within these cloud masses, a large portion of the rain originates as snow at levels where

TABLE 3

Results of Cloud-seeding Operations

Season	Area	Rainfall Increase *per cent*
Spring (Mar., Apr., May)	southern US, Mexico, Central America	20
	northern US, western and south central Canada, central Spain	40
	mountain snowpack operations, US	70
Summer (Jun., Jul., Aug.)	Central America, southern US	20
	northern US, western and south central Canada, central Spain	40
Autumn (Sep., Oct., Nov.)	northern and western US, British Columbia, central Spain	40
Winter (Dec., Jan., Feb.)	northwestern US, central Spain	40
	mountain snowpack operations, US	70–80

temperatures are colder than freezing. The snow is produced by the growth of ice crystals that form upon dust or other foreign particles present in the cloud. From the standpoint of cloud seeding, it is essential to recognize that the mere presence of these freezing nuclei in clouds will not initiate the precipitation process. The response takes place only when cloud temperatures are far below freezing. The production of ice crystals on freezing nuclei takes place within a wide range of temperature, varying from approximately −30°F to as high as +15°F.

The temperature at which the response occurs is a function of the characteristics of the particular substances in the atmosphere. For example, the soil of Nevada provides very poor freezing nuclei, operating at temperatures near −30°F, whereas the soils of South Dakota and North Dakota respond at temperatures near +15°F. The secret of cloud seeding is to disperse through supercooled cloud formations substances that act as freezing nuclei near +32°F. These are capable of inducing additional rainfall from the warm, moist regions of the clouds, usually left untapped by natural nuclei. The skillful development and application of this principle has been responsible for the rapid strides in perfecting the art of cloud seeding to augment water resources in various areas of the world.

Two substances not normally present in the atmosphere, carbon dioxide and silver iodide, become active as freezing nuclei at temperatures much higher than does any other material tested. Therefore, they can be considered effective as artificial nucleating agents to produce precipitation from cloud formations in which temperatures are below freezing. (Such clouds are common within the storm systems of the middle latitudes.) For this purpose, carbon dioxide must be used in the solid form, familiarly known as "dry ice." Experimentation demonstrated very early in the development of cloud seeding that carbon dioxide is ineffectual for widespread, sustained operations over large areas. It must be carried to the clouds either in projectiles or in aircraft and dissipates as it falls through the air. Finally, its expensiveness makes it impractical to use it continuously during the life of a storm—a requirement for operations of commercial significance.

Silver iodide, a yellow powder, can be vaporized to form a myriad of tiny crystals that can be floated through the air to cloud formations, each crystal acting as a freezing nucleus when it ascends to responsive temperature levels. For this reason, silver iodide has been adapted for large-scale commercial cloud-seeding operations, although its use does produce complications that require the perfection of unique skills in order to disperse the material properly and to assure a rendezvous with cloud formations at the target area. At present most commercial cloud seeding operations are conducted from ground-based silver iodide vaporizing generators.

The number of silver iodide crystals injected into cloud formations to induce additional rainfall varies with the particular storm situation. A cloud system is not a static thing; it is sustained by the continuous resupply of moisture provided by the air blowing through it. This rate of resupply is dependent upon the vertical components of motion within the cloud system. Thus, a violent thunderstorm,

characterized by extreme updrafts transporting moisture from lower levels into the clouds, will be supplied with moisture at a much more rapid rate than a less violent storm. The combination of sustained updrafts and constant resupply of moisture causes the mechanisms within the cloud to produce a very high rate of precipitation in forms which, as a result of the supporting vertical updrafts, range from very large raindrops to tremendous hailstones. The cloud seeder uses larger amounts of seeding material to collect moisture for precipitation in storms characterized by a rapid resupply of moisture than in those with a lower rate.

Silver iodide generators with a variable output have been designed to accomplish this purpose. Small amounts of silver iodide, when vaporized at optimum temperatures, produce a great number of freezing nuclei. For example, $\frac{1}{10}$ oz silver iodide vaporized at approximately 2,500°F will form about a million billion crystals, each a potential raindrop producer. A silver iodide generator producing that many crystals per minute can be effective over a sizable target area.

The primary requirement for a successful commercial operation is to maintain continuously a maximum of cloud-seeding effectiveness over the designated operational area during the passage of active rainfall belts. The cloud seeder must make use of special meteorological knowledge pertaining to the dispersion patterns of particulate matter in the atmosphere, under varying wind and temperature conditions, in order to calculate the course which the silver iodide particles will follow from the generators to the temperature levels within the cloud where they take effect. For each storm approaching a project area, a preliminary calculation provides the operator with an indication of cloud-seeding potential. This "cloud-seeding index" is directly related to the storm's natural rainfall capabilities. Once an operational opportunity has been established, the path of the silver iodide particles to their meeting with the clouds is determined from data on measured wind velocities from the ground up to effective seeding levels, and from the rates of ascent of the silver iodide on rising air currents. Such currents, which exist during every storm and ordinarily transport natural nuclei to the clouds, form along the boundaries of interaction between the broad polar and tropical airstreams. The resultant dispersion plumes of silver iodide determine the position at which ground generators must be situated with respect to the target.

Fortunately, in any particular area, all storms bear a relation to their predecessors. Therefore, it is possible, before a project begins, to determine the most likely sites for emplacing ground generators to suit different sets of storm conditions. During an actual storm situation, only those generators that are applicable will be operated. In general, for a target area of several thousand square miles, 10–15 units will be established, only two or three of which will be used during a particular storm.

Methods for targeting cloud-seeding operations accurately have been developed through a long series of studies in which the actual rates of ascent of air, carrying silver iodide, have been measured. Tracer materials exhibiting the same diffusion characteristics as silver iodide have been released and

the patterns studied by aircraft traverses at varying distances from the generators.

In order to control operations effectively, the cloud seeder must receive current information on the state of the atmosphere. The nations of the world maintain an effective exchange of weather information. Communication facilities for the rapid dissemination of these data provide means to effect this control. These basic data have been furnished by the weather service organizations of the world in line with their policy of assisting all activities affected by atmospheric conditions.

In summary, the art of cloud seeding depends on:

1. The use of effective nucleating materials in concentrations related to rates at which the atmosphere resupplies moisture to cloud systems. The rates are determined largely by the vertical rates of motion in the air streams blowing through rain clouds.

2. The ability of the operator to recognize weather situations suitable for cloud seeding. In this regard, a cloud-seeding index is computed which reflects the potential of the atmosphere for producing natural rainfall. The greater this tendency, the higher the index.

3. The ability of the operator to maintain the influence of cloud-seeding operations over a specific area for the duration of a natural rainstorm. This implies a continuous and accurate computation of the horizontal and vertical components of motion that transport artificial freezing nuclei from ground-based vaporizers to their rendezvous at responsive temperature levels within moving cloud sheets. The objective is to build up a cumulative effect in the rainfall pattern over the target area in order to establish a differential with relation to surrounding, unaffected regions. The operator who misses his target a portion of the time, fails to operate each storm, or uses either inferior nucleating agents or improper concentrations, reduces this cumulative effect over the target.

4. The development of sound and effective evaluation techniques to assess the technical and economic results of cloud-seeding operations. Proper evaluation of results forms the keystone for future development and expansion of cloud seeding. It provides the client, as well as the operator, with a means of determining ratios of benefits to costs, and of assessing the relative skills of competitive operators.

Legal Aspects

During its initial phases, cloud seeding was considered a hazardous operation by a large segment of the legal profession. For the most part, these fears were unfounded, being based upon the misconception that one can literally make rain. In truth, cloud seeding does not alter either the time or duration of natural storms; it merely increases the rate of fallout of water from passing cloud systems within natural continuous rain belts. Nevertheless, to avoid unsound practices in the development of cloud seeding, both state and federal legislation has been enacted.

State regulation has taken the form of licensing arrangements to insure high professional standards, avoid overlapping operations by different cloud-seeding organizations, and provide a means of recording all pertinent data. These data, in turn, permit any interested party to assess the results obtained. One state requires insurance

coverage against possible damage to third parties. Colorado and Wyoming enacted such legislation in the spring of 1951. Similar laws were later passed in Arizona, California, Oregon, and South Dakota. In Utah, legislation relating to cloud seeding involves a different aspect. A bill passed in 1952 enables county commissioners to levy an assessment to cover the cost of cloud-seeding operations. Several counties in southern Utah have made use of this law.

The federal government has set up an advisory committee on weather control which will report to the President in 1956. During the early controversial era of cloud seeding, considerable thought was given to the establishment of a commission to regulate such activities. Senate hearings in April 1951 brought out the fact that too little was then known about cloud seeding to frame proper legislation for this purpose. In order to permit research and experimentation to continue on an unrestricted basis, a compromise was made, and the establishment of the advisory committee was the result. The primary purposes of the committee are to evaluate cloud-seeding operations from a technical and economic standpoint, to recommend any regulatory legislation which may seem desirable, and generally to monitor the whole evolution of weather control from both a military and a civilian point of view.

Future Developments

It is anticipated that, during the next decade, the results of cloud-seeding operations will be confirmed and reemphasized until a general acceptance of this process for increasing water resources throughout the world has resulted. As this takes place, increasing allocations of money for research and experimentation can be expected, not only to perfect a basic understanding of atmospheric processes, but also to further the development of the art of cloud seeding for the benefit of mankind. The world will undoubtedly approach true weather control. In all probability, tornadoes, hailstorms, thunderstorms, and other violent atmospheric phenomena can be suppressed, resulting in the saving of many lives and billions of dollars per year. The elimination of lightning will aid in the preservation of forest reserves, where devastating fires caused by it now burn down thousands of acres every year. It may be possible to dissipate hurricanes or to change their course so that they will pass out to sea harmlessly, instead of roaring into populated continental areas with destructive force.

Widespread application of cloud seeding to increase water resources will raise the levels of agricultural and industrial productivity in all parts of the world. This will result in an improvement in man's welfare and perhaps provide an essential condition for outlawing suicidal warfare. The costs of vast irrigation and hydroelectric systems will be reduced because, with more water supplies available, some projects can be eliminated and, in others, the construction of dams and reservoirs minimized. In many instances, interest on the capital investment in the construction of additional water storage will more than pay for cloud-seeding operations to increase the supply sufficiently to make such storage unnecessary.

If man is incapable of recognizing these advantages from cloud seeding

and persists in his efforts to solve world problems through violence, the nation best equipped to control the weather may have the advantage in such a conflict. From a strategic standpoint, such a nation may be able to affect adversely the agriculture and, therefore, the food supply of the enemy. The course of the normal rain-bearing storms responsible for the enemy's agricultural productivity will be altered. The tactical use of weather control to stabilize or dissipate fogs, produce heavy downpours, or otherwise influence the operation of various elements of a military force are not outside the realm of possibility in this era of technological achievement. It is to be hoped, however, that the constructive, rather than the destructive, elements of weather control will be appreciated and utilized to bring about a better world.

Acknowledgment

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Fire Insurance Rating Problems

Panel Discussion

A panel discussion presented on May 27, 1954, at the Annual Conference, Seattle, Wash.

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THE "Standard Schedule for Grading Cities and Towns of the United States With Reference to Their Fire Defenses and Physical Conditions" (*1*) was a natural development of the municipal surveys started by the National Board of Fire Underwriters (NBFU) in 1904. As this work progressed, it was found desirable to establish numerical classifications for the degree of fire protection provided by a city, so that they could be used as a guide in the underwriting procedure of the NBFU member companies. The preparation of the schedule, which was begun in 1914, was facilitated by the knowledge gained by NBFU engineers during 10 years of experience in making field surveys of cities throughout the country. The first edition of the schedule was published in 1916, and there have been several later editions. Although the schedule was designed for utilization by NBFU member companies, eventually almost all of the fire insurance inspection boards and bureaus in the country came to consider it a useful means of establishing the classification of cities and towns.

Grading System

The basic principle of the schedule is that standards are set up for the various items affecting the adequacy and reliability of water supply systems and other features of fire prevention and protection, including the fire department, fire alarm system, building laws, and structural conditions. Points of deficiency are assigned depending upon the extent of variance from these standards. These standards are not arbitrary but are the result of experience in many city surveys and the application of fundamental engineering principles. They follow the best practices in actual operation and they have been subject to critical review by water superintendents and others interested in fire protection. The standards set forth are those which, if complied with, will provide reasonably adequate and reliable fire protection.

A study of the water supply gradings made by NBFU engineers in the past 30 years yields many interesting facts. During that period 487 cities—including almost all those with 25,000 population or more—have been surveyed, most of them from two to six times, making a total of about 1,500 gradings. A large number of gradings of small communities have been made by the various state rating bureaus.

The maximum total number of points of deficiency possible under the heading of water supply is 1,700. Thus, if the cities surveyed are divided into ten classes, the first would comprise those cities having 170 points or

less, the second 171–340 points, and so forth. The average of the latest water supply gradings of the 487 cities is 382 points of deficiency, which would fall into the third class. The number of cities in each class, from first to tenth, respectively, is 62, 167, 138, 87, 23, 8, 1, 1, 0, and 0. The best city has 35 points of deficiency, the worst 1,264 points. Of the 487 water supplies graded, 89 are gravity systems and 398 have pumping. The gravity systems average 273 deficiency points, the pumping systems 406 points.

Of the 62 cities in the first class, 23 have less than 100 points. Three first-class cities have separate high-pressure systems, and 26 have gravity systems. The average of the gravity systems is 120 points; that of the pumping systems is 122 points. The majority of the first-class systems are in the North Atlantic States and are mainly systems whose growth has been slow but substantial, with a long period of water supply experience.

The water supply section of the grading schedule includes 32 items covering the adequacy and reliability of all features that have a bearing on fire protection. Adequacy involves the ability of the system, when functioning under normal conditions, to deliver the required fire flow; this depends on the sizes of mains, both arterial and branch; the capacity of the pumps; the amount of storage, both suction and elevated; the capacity of boilers and generators; and the spacing and size of hydrants. Reliability involves the ability of the system to deliver the fire flow under adverse conditions resulting from an accident or unusual occurrence. This phase includes the effect of floods, broken mains, pumps out of service, breaks in steam or power lines, hazardous conditions at the pumping or generating station, spacing of gate valves, and condition of valves and hydrants.

Important Items

Some of the more important items will now be discussed in detail. Item 6 of the schedule is the most significant, not only in itself, but because several of the other items are influenced by it. This item concerns the normal ability of the source, and each part of the supply works including the mains, to sustain maximum consumption demands and deliver the required fire flow to the congested high-value district at 20-psi pressure (or in some instances, 10 psi) for a period of 10 hr in cities of the size under consideration in this paper. To determine the maximum consumption demands, the maximum day rather than the peak hour is used.

The required fire flow is derived from a formula based on actual experience with many fires. The population is the governing and generally the sole factor, although some allowance may be made for unusual structural conditions and consideration must also be given to the strength of the fire department and the amount of outside aid that could be called upon in a serious fire. The quantity of water available is determined by fire flow tests, with due allowance for the consumption rate at the time of the tests. Of the 487 cities surveyed, adequate quantities were obtained at the strongest point in the high-value district in 324 cities, or 68 per cent; in the majority of the remaining 163 cities, the quantity available was not far below that required. It is well to note that, in some of the latter, the full required fire flow could be obtained for a period shorter than 10 hr, which is consid-

ered the possible duration of a serious fire. There may be elevated storage that could be exhausted in less than 10 hr, leaving only the pumping capacity available; or there may be a small amount of clear-water storage that will give an adequate supply for a time but, when exhausted, will leave the filter capacity insufficient for combined consumption and fire demands. Fire flow tests are primarily a measure of the distribution system, which is not always the limiting feature. When storage is available, due credit is, of course, given for it, divided over a 10-hr period.

Another item, of importance in pumping systems, is No. 8, which relates to reserve pumps. In order to meet NBFU standards fully, there should be enough pumps so that the combined fire flow and maximum consumption can be supplied at any time during a 5-day period with the two largest units out of service. The deficiency-point charge for the second pump out of service is relatively small. Here again credit is given for storage. This requirement has been thought severe by some, but, of the 398 pumping systems surveyed, 147 met it fully, and in many others the deficiency was small.

The matter of construction and protection of the pumping station is one that deserves much attention. Fires in pumping stations are not unheard of, by any means. The station should be fireproof, and this requirement was substantially met in 131 cities; adequate fire protection, consisting of hose and extinguishers, was provided in 255; a few pumping stations were protected by automatic sprinklers.

A very important item is No. 16, concerned with the effect on maximum consumption and fire flow of a break in supply mains, pumping station suction and discharge mains, connections at reservoirs and filter plants, or other critical points. On the assumption that the most serious break possible has occurred, the deficiency may be considered offset if the remaining mains, from the source of supply and storage, can provide the fire flow for 10 hr during a 5-day period of maximum consumption. Of the cities surveyed, 60 fully met the requirement for the worst break that can occur. Many other places had only a small deficiency in this item.

Item 20 concerns the ability of small mains to deliver fire flow and maximum consumption, under normal conditions, to all parts of the district, and the deficiency is based on the amount available at the weakest point. In 202 cities, or 42 per cent of the total surveyed, no points were charged for this item.

It is important that sufficient gate valves be installed so that, in the event of a break, a minimum number of hydrants will be put out of service. In the cities considered, 91, or 19 per cent, fully met NBFU standards.

If the fire department is to obtain the amount of water that the mains can supply, there must be sufficient hydrants of adequate size and they must be maintained in good condition. The spacing of hydrants must be such that the fire department can concentrate the required water on the fire without hose lines of excessive length. It is obvious that the spacing varies with the fire flow required; the area per hydrant ranges from 40,000 sq ft in the high-value district of a large city to 120,000 sq ft in residential sections. In actual practice, this means an average linear

spacing of 200–350 ft. Of the 487 cities under discussion, 230, or 47 per cent, fully met NBFU standards for the high-value district; for residential districts, only 45 cities, or less than 10 per cent, met the standards.

Improvement in Gradings

Perhaps a word on general improvement in gradings may not be amiss. A comparison of original gradings with the latest made—the average period between ratings is about 10 years—shows an average improvement of 121 points, or approximately 25 per cent. In many cities, there has been much greater improvement. For example, the water supply of one southeastern city, with a population of 45,000, was rated seventh class (1,021–1,190 deficiency points) in 1928. At that time, the supply from wells was little more than enough to meet maximum consumption, with inadequate suction storage for fires. There was no elevated storage and no reserve anywhere. In addition, the mains were too small to deliver the fire flow even if it had been available at the source, and hydrants and gate valves were far too widely spaced. Subsequent gradings showed steady improvement. Additional wells were provided, together with elevated storage, increased suction storage, and pumps; and the distribution system was substantially strengthened. Now the water supply is second class (171–340 points), approaching first.

A city in the Middle West, with a population of 60,000, had a fourth-class water supply in 1925. The most serious inadequacy was in wells and pumps, although there were other grave weaknesses. Thirteen years later almost all of these conditions had been remedied, and the grading was first class, with only 61 points of deficiency—one of the best ratings in the country.

The improvement in the water supply systems of these and many other municipalities has been greatly influenced by the recommendations contained in NBFU municipal fire protection reports. These are published in connection with each grading and are given to the interested public officials for their consideration. As the recommendations in these reports are based upon the standards set forth in the grading schedule, the large degree of compliance is an indication that these standards are regarded as reasonable from an engineering standpoint and have been generally accepted by the water works profession as a good measure of the adequacy and reliability of water supply systems from the fire protection standpoint.

Reference

1. *Standard Schedule for Grading Cities and Towns of the United States.* Natl. Board of Fire Underwriters, New York (1942); *Jour. AWWA,* **34**: *following p.* 1584 (Oct. 1942).

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The relationship between the NBFU and local boards or bureaus differs throughout the United States, but, in general, NBFU applies the grading schedule to cities with more than 35,000 population, while either the state rating bureau or one of the regional boards, such as the Southeastern Underwriters or the Board of Fire Underwriters of the Pacific, applies the schedule to smaller communities. If

there is any question about whom to get in touch with regarding the grading of a particular city, the following rule may prove useful: if the population is more than 35,000, inquire of the NBFU at its New York, Chicago, or San Francisco office; if the population is less than 35,000, check with the local rating bureau, which will be able to provide this information when it does not do the grading itself. The state insurance department will also be glad to provide assistance.

The schedule previously described (see page 818) is applied to small cities as well as to large ones, just as the same ruler can be used to measure the width of a board or the width of a room. Some difficulties encountered in small communities, however, should be pointed out. It takes the same amount of water to extinguish a fire in buildings of the same construction and occupancy, regardless of the size of the city in which they are located. This amount of water may be many times the normal demand on the water system in a small town, while it would be just a drop in the bucket for a metropolis. Consequently, large-city water systems usually grade better than those of smaller communities. Another difficulty frequently encountered in small cities is the lack of adequate records. The manager of a small system not only has to handle administrative matters but probably has to check the bills, read the meters, do most of the collection, and help out in laying pipe and fixing pumps. He does not feel the need for records because he knows his system thoroughly, and he has no time to prepare them for his successors. Obviously, this condition does not result in the most efficient water supply operation and is possibly another reason why small systems grade worse than large ones.

Grading information on small towns is important to insurance companies, for, even in a small community, they have millions of dollars of liability. Their interest is not, however, limited to rating a town; they are also desirous of furthering improvements in water systems and fire departments, so that the loss of a considerable amount of money can be avoided. It is evident that the water superintendent, the underwriters, and the public have compatible interests. They all want to make the water system the best that can be afforded, and this objective can be achieved through the cooperation of all concerned.

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The premium or cost of fire insurance depends upon two general factors: the extent of coverage, which the insurance buyer can control; and the rate applicable to the property covered, which is largely beyond his control. The latter factor will be discussed here, stressing primarily the elements that are of especial interest to the water works profession. In its effort to separate the high potential fire loss risks from the low ones, the business of fire insurance rating has, through the years, become very complex. Within the limited space allotted for this discussion, only the highlights can be explored.

At least one rating organization is operating within each state or Canadian province to promulgate advisory fire insurance rates for the guidance of subscribing underwriters. Schedules

designed to produce rates that are adequate, reasonable, and not unfairly discriminatory are prepared and filed, according to law, with state insurance commissioners. To be adequate, rates must be set at a level to meet anticipated losses in the properties insured, as well as acquisition costs (insurance company underwriting expenses). It is found that these conditions differ appreciably from place to place and year to year, a fact that accounts for the variance in rates in the several states. Anticipated losses may be determined with fair accuracy from past experience, the accuracy of such forecasts being directly proportional to the elements of time (the period over which records have been kept) and space (the extent of the area under observation). Fire loss experience, however, also reflects ever changing physical conditions and may result in periodic modification of the rate level.

Among the various jurisdictions, there is no uniformity in the derivation of fire insurance rates on buildings and their contents, but all are agreed on the fundamental factors that influence fire loss: construction, occupancy, exposure, and protection.

In risks requiring special rating, each of the first three factors is carefully scrutinized in considerable detail, and a rate is established through the application of filed schedules. Generally speaking, the rate thus developed on any specified risk would be identical wherever located in the rating jurisdiction, and would be modified only in accordance with the prevailing protection factor in the area. The protection factor may be ascertained through the application of the "Standard Grading Schedule," which, by the way, is the one schedule in the insurance industry endorsed and adopted in practically all jurisdictions.

Protection Classes

In the state of Washington, rating schedules are designed to recognize only ten classes of protection, as suggested in the grading schedule. When a classification has been established for a municipality, it is applicable to all property within the corporate limits. Almost all risks, including dwellings, are affected by each change in classification, from unprotected to the very best grading. This practice has been found to promote good public relations, as most of the people that pay the fire protection bill are thus directly concerned. A number of rating organizations further subdivide the ten classes to provide intermediate protection credits, and, in some, the dwelling rate is not always affected by successive changes in classification. Where protection facilities surrounding a risk—for example, a remote manufacturing plant—differ substantially from those expected for the general class applicable in its locality, the protection around such risks is specially classified through the application of an exterior-protection schedule. This schedule stresses, among other items, the sufficiency of fire hydrant installations. In Washington, dwellings within the so-called hydrant area enjoy a somewhat better insurance rate than those far from fire hydrants. This practice is looked upon with favor by most water works operators, because it encourages better water distribution design and desirable fire hydrant installations.

Regardless of the methods employed by the various rating organizations, successive changes in the protection

classification result in a general change in the level of fire insurance rates applicable in the affected locality. The credit may be reflected in the basic rate for certain types of risks, or it may be applied as a percentage after the basic unprotected building rate has been determined. Very often the exposure factor is also modified and other benefits are derived from an improvement in the class of protection. As an example of how protection affects fire insurance costs, the rate on a modern frame dwelling with wooden shingle roof under full protection in Seattle, Wash., which grades Class 2, is approximately 70 per cent less than the rate charged on an identical building in unprotected, or Class 10, situations.

Automatic Sprinkler Systems

Because fire defense is largely dependent upon adequate water supplies, the water works operator, in conjunction with the fire-fighting forces, shares a heavy responsibility in this matter. In a major portion of the fire calls answered, little or no water is required. In many cities, more water from fire hydrants is used for street washing and sewer flushing than in combating fire. Nevertheless, any fire department is helpless in controlling large fires without adequate and reliable water supplies. Furthermore, the present trend toward large, unrestricted manufacturing and mercantile buildings poses an almost impossible situation for the exterior fire defense facilities and brings into focus the need for fixed interior extinguishing devices. Foremost in this field is the automatic sprinkler system. The value of such systems in safeguarding life and property from fire is beyond question, as literally thousands of potentially disastrous fires have been extinguished with little or no loss, and with negligible quantities of water—a fact that should be of interest to water works operators. Hundreds of such fires are not even reported. On the other hand, major fires in sprinklered risks that come to the public's attention usually result from faulty installations, poor maintenance, or inadequate and unreliable water supply.

Despite the outstanding record of fire extinguishment by automatic sprinkler systems with relatively small amounts of water, owners desiring to install such systems still encounter considerable resistance from many water works operators through the imposition of unrealistic connection and service charges. Where, as usually happens, such service requires no expansion of water works facilities, the charges should be held to a minimum in order to encourage these installations.

A water system designed to provide adequately for exterior fire-fighting facilities is also adequate to handle the lesser needs of a sprinkler system. Insurance companies recognize the value of automatic sprinkler systems through a very substantial reduction in fire insurance rates on properties so protected. Although this saving is important momentarily, of greater significance is the security such a system offers to the operation protected and, indirectly, to the community as a whole. In fact, the insurance saving is often largely absorbed by the added investment, maintenance, and service charges. It may be said that any property owner who protects his property with a sprinkler system, either voluntarily or because of pressure from constituted authorities, benefits not only himself but also the public, by reducing

the possibilities of conflagration, loss of jobs, and destruction of capital assets in the community. Actually, the beneficial effect extends far beyond the immediate area. The encouragement of automatic sprinkler systems will profit the water department by reducing the amount of water used for fire extinguishment.

Conclusion

It is evident that the community itself largely determines the standard of protection it can or will maintain, which, in turn, is reflected in the fire insurance rates applicable therein. But when a really big fire is in progress, it is the joint responsibility of the fire and water departments to get it under control. Unfortunately, too often it is only then that the services of these departments are appreciated by the community.

For readers desiring to pursue the subject of municipal fire administration further, a book (*1*) prepared by the International City Managers' Assn., Chicago, is recommended.

Reference

1. *Municipal Fire Administration.* Intl. City Managers' Assn., Chicago (5th ed., 1950).

Henry R. Herold

Assoc. Engr., Water Dept., Seattle, Wash.

The preceding discussions have explained the underwriters' approach in analyzing a water system. Water works officials realize the importance of an adequate and reliable system, and experience has generally taught them what is required. A few observations from the operator's point of view may be worth while.

Proposed supply increases, pipelines, pumping stations, and trunk distribution grid additions should be planned as far ahead as possible, so that they will be compatible with future development and so that financing will be available when required.

The importance of setting system standards cannot be overemphasized. If everyone knows the requirements and realizes that they are uniformly enforced, the pressure to lower them will be minimized. Any letdown in standards is sure to be followed by demands for further relaxations. Where conditions make it impossible to meet the requirements fully, it would be better to install a minimum temporary system rather than one that is almost good enough. It is much more difficult to justify replacing an almost adequate installation than a temporary one.

Many cities are expanding by annexations. Suburban areas desire city services. Water distribution systems must be extended or existing systems taken over. Frequently one of the pressing reasons for annexation is the lack of adequate water facilities.

The forward-looking water works official will foresee these annexations and extensions and will do everything practicable to encourage city standards in fringe areas. Extension of direct municipal water service into contiguous areas, in advance of annexation, is desirable to forestall inadequate and haphazard extensions by others. Thus, at least partial control of standards may be possible.

Many suburban developers are now employing enclosed plats, leaving only a minimum of access roads to residential districts. Water works officials, as well as those of other utilities,

should see that they are consulted on the access required for their utilities before plats are approved. The proportion of dead-end streets is greater than was formerly the practice. Thus, larger trunk mains will be required on the remaining thoroughfares. In the past the distribution grid in each street furnished some of the trunk capacity.

The installation cost of a 4-in. pipe per unit of capacity is about four times that of an 8-in. pipe in the same situation. When laying conditions are difficult, or when there is interference with traffic or pavement to cut and replace, the difference in cost per unit of capacity may become much greater. Consequently, it is not always the best practice to figure pipe requirements too closely in order to install the smallest possible size. The data upon which the calculations were based often change. Replacements to supply added capacity could more than offset the original savings. It is not difficult to see that a 4-in. line of any great length cannot supply the average fire department pumper with a capacity of 750 gpm when the friction loss in 100 ft of such a pipe is 15 psi, feeding from one direction, or 4 psi, feeding from both directions.

When an underwriters' board surveys a city, it makes flow checks at a number of representative locations and establishes how nearly the water system meets the standards set. The survey report includes point-by-point findings and recommendations, not only on the water supply but also on the fire department and other features that determine the classification. This information is of great value in planning additions and extensions to a water system.

Basis for Review of Meter Installations

By James G. Carns Jr.

A contribution to the Journal by James G. Carns Jr., Meter Engr., American Water Works Service Co., Philadelphia.

ONE of the perennial problems of water works operation is the question of proper meter size and type for any given installation. This question is often complicated by service lines of inadequate size. The tendency in recent years has been to install larger services, particularly for commercial and industrial accounts. This trend has been caused by changes in customer demand and the high cost of replacing services that are found to be too small. Such an approach is a sensible one to adopt, for three reasons: [1] the number of large service installations is very small compared to the total number; [2] the cost of replacing even a few inadequate services is out of all proportion to the cost of installing larger ones initially; and [3] with adequate service size, more accurate measurement of water use can be obtained by proper meter selection, particularly when provision is made in the original installation for removing, repairing, and testing the meters.

Most water works men today realize that the best meter installation is the smallest one of proper design that will provide for the range and frequency of flow rates experienced. Lack of knowledge of the probable maximum demand of various types of establishments, however, leads to considerable divergence of opinion on meter sizing. Even if such data were available, good judgment would dictate a margin of safety to provide for business expansion, technological changes, and similar contingencies. Therefore, it is not possible to select a meter size for large accounts that will be permanently satisfactory.

The American Water Works Service Co. has endeavored to establish flexibility in meter installations larger than 2 in. by providing a piping layout (Fig. 1) that permits the sizes, types, and number of meters to be changed with a minimum of expense to meet changed service requirements. The spring-loaded back-pressure valves in Fig. 1 are designed to open with a pressure differential of 2 psi or more and divide the flow through two or three meters, except when demands are small. Low rates of flow are measured by one meter only. Special bronze adapters are used to reduce meters in service from 2 in. to any smaller size without having to resort to piping changes.

Extreme difficulty has been encountered in designing suitable meter arrangements for services installed many years ago when standard practice seemed to be to employ a meter of the same size as the service and to make no provisions for repairing, testing, or replacing the meter. In its attempts to

TABLE 1

Monthly Continuous Meter Registration

Per Cent of Safe Maximum Operating Capacity*	Meter Size and Type													
	¾-in. Disk	¾-in. Disk	1-in. Disk	1½-in. Disk	2-in. Disk	3-in. Disk	3-in. Compound	3-in. Current	4-in. Disk	4-in. Compound	4-in. Current	6-in. Disk	6-in. Compound	6-in. Current
30-day Continuous Registration—*1,000-gal units*														
10	86	130	216	432	691	1,296	1,382	1,728	2,160	2,160	3,024	4,320	4,320	6,912
20	*173*	*259*	*432*	*864*	*1,382*	*2,592*	2,765	3,456	*4,320*	4,320	6,048	*8,640*	8,640	13,824
30	259	389	648	1,296	2,074	3,888	4,147	5,184	6,480	6,480	9,072	12,960	12,960	20,736
33⅓	—	—	—	—	—	—	*4,608*	*5,760*	—	*7,200*	*10,080*	—	*14,400*	*23,040*
40	346	518	864	1,728	2,765	5,184	5,530	6,192	8,640	8,640	12,096	17,280	17,280	27,648
50	432	648	1,080	2,160	3,456	6,480	6,912	8,640	10,080	10,080	15,120	21,600	21,600	34,560
60	518	778	1,296	2,592	4,147	7,776	8,294	10,368	12,960	12,960	18,144	25,920	25,920	41,472
70	605	907	1,512	3,024	4,838	9,072	9,677	12,096	15,120	15,120	21,168	30,240	30,240	48,384
80	691	1,037	1,728	3,456	5,530	10,368	11,059	13,824	17,280	17,280	24,192	34,560	34,560	55,296
90	778	1,166	1,944	3,888	6,221	11,664	12,442	15,552	19,440	19,440	27,216	38,880	38,880	62,208
100	864	1,296	2,160	4,320	6,912	12,960	13,824	17,280	21,600	21,600	30,240	43,200	43,200	69,120
30-day Continuous Registration—*1,000-cu ft units*														
10	12	17	29	58	92	173	184	230	288	288	403	576	576	922
20	*23*	*35*	*58*	*115*	*184*	*346*	369	461	*576*	576	806	*1,152*	1,152	1,843
30	35	52	86	173	277	518	553	691	864	864	1,210	1,728	1,728	2,765
33⅓	—	—	—	—	—	—	*614*	*768*	—	*960*	*1,344*	—	*1,920*	*3,072*
40	46	69	115	230	369	691	737	922	1,152	1,152	1,613	2,304	2,304	3,686
50	58	86	144	288	461	864	922	1,152	1,440	1,440	2,016	2,880	2,880	4,608
60	69	104	173	346	553	1,037	1,106	1,382	1,728	1,728	2,419	3,456	3,456	5,530
70	81	121	202	403	645	1,210	1,290	1,613	2,016	2,016	2,822	4,032	4,032	6,451
80	92	138	230	461	737	1,382	1,475	1,843	2,304	2,304	3,226	4,608	4,608	7,373
90	104	156	259	518	829	1,555	1,659	2,074	2,592	2,592	3,629	5,184	5,184	8,294
100	115	173	288	576	922	1,728	1,843	2,304	2,880	2,880	4,032	5,760	5,760	9,216
Safe Maximum Operating Capacity*—*gpm*														
	20	30	50	100	160	300	320	400	500	500	700	1,000	1,000	1,600

* "Safe maximum operating capacities" (in gallons per minute) apply only for short periods of operation or peak loads occurring at long intervals. To avoid possible excessive wear, disk meters should not be operated continuously at more than 20 per cent of the safe maximum operating capacity; compound or current meters should not be operated continuously at more than 33⅓ per cent of the safe maximum operating capacity. The 30-day continuous registration equivalent to these percentages is shown in italics for each meter.

redesign existing meter installations, the author's company has often found the cost prohibitive, as the probable increase in registration, and revenue, must be very great to justify the expense involved.

Table 1 has proved valuable in conjunction with a preliminary review of meter registration data to provide more efficient installations. Conclusions reached from such a study are, of course, verified by more detailed data before final decisions are made regarding a specific installation. This tabulation, based on safe maximum operating capacities for meters as given in AWWA specifications, shows the 30-day total registration for meters operated continuously at constant rates. The italicized figures are the maximum registrations that should occur in 30 days of continuous operation if the meters are not to be overworked, with resultant excessive wear. A few examples will illustrate some of the ways in which this table is helpful:

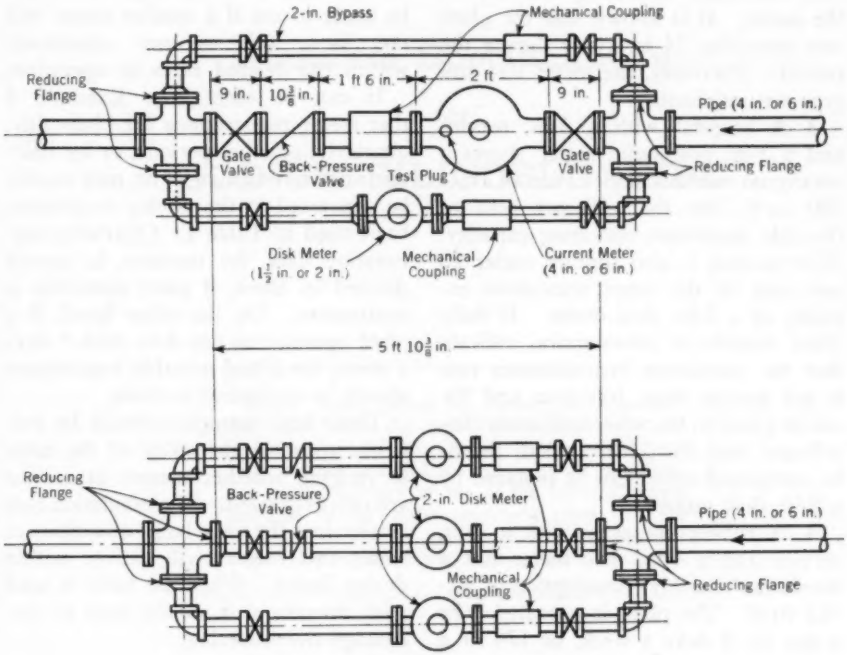

Fig. 1. Flexible Meter Installations

The upper drawing shows piping arrangements for a 4-in. or 6-in. current meter; the lower shows connections for one, two, or three 2-in. disk meters.

1. A large industrial account served through a 6-in. service and a 4-in. current meter has a maximum monthly registration of 2,155,200 cu ft. By referring to the table, it can be seen that this meter, *if operating continuously*

for 30 days at a constant rate, is working at slightly more than 50 per cent of capacity, which is sufficient to cause excessive wear.

2. The same conditions exist as in Example 1, except that the maximum monthly registration is 1,097,300 cu ft, or approximately 25 per cent of the safe maximum operating capacity of the meter. It is known that the plant was operating 24 hr a day during the period. Therefore, the meter size and type are satisfactory.

3. A hospital with a 3-in. service and a 3-in. compound meter shows a maximum monthly registration of 169,500 cu ft, less than 10 per cent of the safe maximum operating capacity. This amount is also slightly under 20 per cent of the rated maximum capacity of a 2-in. disk meter. If daily chart records of consumption indicate that the maximum instantaneous rate is not greater than 160 gpm and the use is found to be rather uniformly distributed over the 24-hr period, the 3-in. compound meter can be replaced by a 2-in. disk meter.

4. A rubber company with a 4-in. service and a 4-in. disk meter has a maximum monthly consumption of 50,912 cu ft. The plant is operated 8 hr a day for 5 days a week, or 176 hr a month. Table 1 is based on $30 \times 24 = 720$ hr, or 4.1 times the actual period of operation. To use Table 1, the 50,912 figure is multiplied by 4.1, giving 208,000 cu ft as the 30-day continuous registration. This amount is less than 10 per cent of the maximum safe operating capacity of 4-in. disk meters. Therefore, further investigation should be made to see if a smaller meter will not serve this account adequately within the desired rates of operation.

It can be seen from Example 4 that meter registrations for bimonthly, quarterly, or other periods, or for daily operation of less than 24 hr, may readily be converted to the 30-day continuous basis used in Table 1. Quarterly registration data, for instance, is merely divided by three, if plant operation is continuous. On the other hand, if a plant operates on one 8-hr shift 7 days a week, the actual monthly registration should be multiplied by three.

These few examples should be sufficient to show the value of the table in judging whether meters in service are properly sized. The tabulation also emphasizes the very large quantities of water that meters will deliver within design limits. When the table is used with discretion, it should tend to discourage overmetering.

American Water Works Association

Tentative

Standard Specifications

for

SODIUM SILICOFLUORIDE

These "Specifications for Sodium Silicofluoride" are based upon the best known experience and are intended for use under normal conditions. They are not designed for use under all conditions and the advisability of use of the material herein specified in any water treatment plant must be subjected to review by the chemist or engineer responsible for operations in the locality concerned.

Approved as "Tentative" May 27, 1954

● **Price of reprint—20¢ per copy**

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These "Specifications for Sodium Silicofluorides" were prepared under the direction of J. E. Kerslake for the Water Purification Division, AWWA. The specifications were approved by the Executive Committee of the Water Purification Division and by the Water Works Practice Committee, and received the approval of the Association's Board of Directors on May 27, 1954. They were also submitted for review to producers and consumers of the materials involved, whose comments were then considered by A. R. Todd, acting as referee.

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Tentative Standard Specifications for

Sodium Silicofluoride

Part A—Material Specifications

Sec. 1A—Scope

These specifications cover sodium silicofluoride (Na_2SiF_6), also known as sodium fluosilicate, for use in the treatment of municipal and industrial water supplies. The specifications are intended for use in connection with Part B (Sampling, Inspection, Packing, and Marking) and Part C (Testing Methods) of this document.

Sec. 2A—Definition

Sodium silicofluoride is a white or yellowish-white, nonhydroscopic, crystalline powder containing no water of crystallization. It may be colored blue for purposes of identification. The coloring-material content shall not exceed 0.30 per cent of the sodium silicofluoride by weight. The sodium silicofluoride container shall be labeled "poison" and have an antidote printed on the label. Sodium silicofluoride is sparingly soluble in water, varying from 0.03 lb per gallon at 32°F to 0.12 lb per gallon at 140°F. The pH of a 1 per cent solution is 3.5.

Sec. 3A—Caution in Handling

Sodium silicofluoride dust is toxic. Men handling this material should wear protective clothing, respirators, and goggles. They should be given detailed safety instructions. All equipment for handling sodium silicofluoride, such as storage bunkers, weigh hoppers, and dry-feed machines, should be provided with devices to keep the dust hazard at a minimum.

Sec. 4A—Sampling

Sampling shall be conducted in accordance with Part B (Sampling, Inspection, Packing, and Marking) of this document.

Sec. 5A—Method of Testing

The laboratory examination shall be carried on in accordance with Part C (Testing Methods) of this document.

Sec. 6A—Impurities

The sodium silicofluoride supplied under these specifications shall contain no soluble mineral or organic substances in quantities capable of producing deleterious or injurious effect upon the health of those consuming water which has been treated properly with sodium silicofluoride.

Sec. 7A—Rejection

7A.1. Notice of dissatisfaction with a shipment, based on the specifications, must be in the hands of the consignor within 10 days after receipt of the shipment at the point of destination. If the consignor desires a retest, he shall notify the consignee within 5 days of notice of the complaint. Upon receipt of the request for a retest, the consignee shall forward to the consignor one of the sealed samples (see Sec. 2B.5). In the event that the results

obtained by the consignor, on retesting, do not agree with the results obtained by the consignee, the other sealed sample shall be forwarded unopened, for analysis, to a laboratory agreed upon by both parties. The results of the referee analysis shall be accepted as final, and the cost of the referee analysis shall be paid for by the party whose results show the greatest discrepancy from the referee results.

7A.2. On the basis of the retest or the referee test, the consignor may remove the material from the premises of the consignee, or a price adjustment may be agreed upon by the consignor and consignee.

Sec. 8A—Size

The material shall be a dry powder containing no large lumps, shall be free flowing, and shall be suitable for storage in closed hopper bins and for feeding in a dry-feed machine.

Sec. 9A—Insoluble Matter

The insoluble matter shall not exceed 0.5 per cent.

Sec. 10A—Moisture

Moisture shall not exceed 0.5 per cent.

Sec. 11A—Sodium Silicofluoride Content

The sodium silicofluoride shall have a minimum of 98 per cent sodium silicofluoride (Na_2SiF_6), which corresponds to approximately 59.4 per cent fluoride (F).

Part B—Sampling, Inspection, Packing, and Marking

Sec. 1B—Scope

These procedures for the sampling, inspection, packing, weighing, and marking of sodium silicofluoride are intended for use in connection with Part A (Material Specifications) and Part C (Testing Methods) of this document.

Sec. 2B—Sampling

2B.1. Samples shall be taken at the point of destination.

2B.2. If the sodium silicofluoride is handled by a conveyor or elevator, a mechanical sampling arrangement may be used.

2B.3. If the material is packaged, 5 per cent of the packages shall be sampled. No sample shall be taken from a broken package.

2B.4. Sodium silicofluoride may be sampled by the use of a sampling tube which is at least $\frac{3}{4}$ in. in diameter.

2B.5. The gross sample, weighing at least 16 lb, shall be mixed thoroughly and quartered to provide three 1-lb samples. These shall be sealed in airtight, moistureproof glass containers. Each sample container shall be labeled to identify it, and the label shall be signed by the sampler.

Sec. 3B—Packing and Shipping

3B.1. Sodium silicofluoride may be shipped in multiwall paper bags containing 100 lb net weight each; in fiber drums containing 125, 375, or 400 lb net weight each; and in barrels containing 375 lb net weight each.

3B.2. The net weight of the packages shall not deviate from the recorded weight by more than 2.5 per cent, plus or minus. If exception is taken to the weight of the material received, it shall be based on a certified unit weight of not less than 10 per cent

of the packages shipped, selected at random from the entire shipment.

Sec. 4B—Marking

Each package of material shall carry with it some means of identification and a warning of its potential danger. The warning label shall be in accordance with the recommendations of the Manufacturing Chemists Assn.,* Washington, D.C. The identification shall consist of a red band (minimum width 3 in.) all the way around the midsection of each package or container of sodium silicofluoride. Each package shall have marked legibly thereon the net weight of the contents, the name of the manufacturer, a brand name, if any, and such other markings as required by applicable laws. The package may bear also the statement: "Guaranteed by (name of manufacturer) to meet the specifications of the American Water Works Association for sodium silicofluoride."

Part C—Testing Methods

Sec. 1C—Scope

These methods for the examination of sodium silicofluoride are intended for use in connection with Part A (Material Specifications) and Part B (Sampling, Inspection, Packing, and Marking) of this document.

Sec. 2C—Sampling

2C.1. Sampling shall be conducted in accordance with Part B (Sampling, Inspection, Packing, and Marking) of this document.

2C.2. The sample delivered to the laboratory shall be quartered to approximately 100 g. After thorough mixing, this sample shall be stored in an airtight glass container and weighed out rapidly to avoid change in moisture content.

2C.3. Laboratory examination of the sample shall be completed within 5 working days after receipt of the shipment.

2C.4. Samples shall be stored for at least 30 days after the date of receipt before disposal.

Sec. 3C—Insoluble Matter

3C.1—*Procedure:*

3C.1.1. Weigh 2 g of sample that has been previously dried for 2 hr at 105°C, or until constant weight has been reached. Dissolve in 500 ml of hot distilled water.

3C.1.2. Filter through a tared Gooch crucible or a tared fritted-glass filter of medium porosity. Transfer the insoluble matter carefully to the crucible and work until the washings no longer give positive results to a test for fluoride. Dry the crucible or fritted-glass filter at 105°C to constant weight.

3C.2—*Calculation:*

$$\frac{\text{Weight of residue} \times 100}{\text{Weight of sample}} = \text{per cent insoluble matter}$$

Sec. 4C—Moisture

4C.1—*Procedure:*

Weigh 5 g of sample into a broad weighing bottle and heat in an oven at 105°C for 2 hr, or until constant

* The recommended wording for warning labels on sodium silicofluoride containers is given in Manufacturing Chemists Assn. Manual L-1, page 60 (2nd revision, 1949), as follows:

WARNING! May be fatal if inhaled or swallowed.

1. Avoid breathing dust.
2. Wash thoroughly after handling.
3. Clean up spillage.

weight is reached. Cool in a desiccator and weigh.

4C.2—*Calculation:*

$$\frac{\text{Loss in weight} \times 100}{\text{Weight of sample}} = \text{per cent moisture}$$

Sec. 5C—Sodium Silicofluoride

5C.1—*Reagents:*

(a) Alcoholic potassium chloride solution: dissolve 60 g potassium chloride in 400 ml of recently boiled and cooled distilled water, and add 400 ml of 95 per cent neutral ethyl alcohol

(b) Alcoholic potassium chloride and sodium carbonate solution: prepare by saturating Reagent (a) with sodium carbonate

(c) Standard sodium hydroxide solution, 0.2*N*, carbonate free

(d) Phenolphthalein indicator, 1 per cent.

5C.2—*Procedure:*

5C.2.1. Weigh into a platinum dish 0.5 g of sample that has been dried to constant weight. Add rapidly, with continuous stirring, enough of Reagent (b) to insure alkalinity. The solution must not be allowed to become acid.

5C.2.2. Filter with suction and wash with Reagent (a) until the wash liquid is not alkaline to phenolphthalein.

5C.2.3. Transfer the filter and residue to a beaker and add 100 ml of recently boiled and cooled distilled water. Heat to 70°–90°C and titrate with 0.2*N* sodium hydroxide, using phenolphthalein indicator. Continue heating and complete the titration with the solution actively boiling.

5C.3.—*Calculation:* *

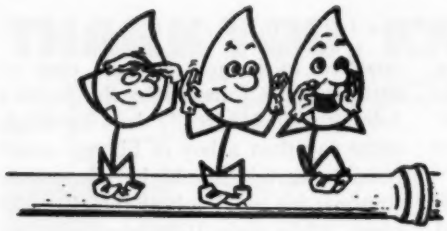
$$\frac{\text{ml } 0.2N \text{ NaOH} \times 0.0094 \times 100}{\text{Weight (g) of sample}} = \text{per cent sodium silicofluoride } (Na_2SiF_6)$$

NOTE: Because of the high degree of purity (98 per cent) required for sodium silicofluoride by this specification, the list of limitations on impurities, together with recommended tests for them, has been omitted. If such limitations and tests are of interest, refer to Sec. 6C, 7C, 9C–12C of the Standard Specifications for Sodium Fluoride—AWWA B701. (In Sec. 12C of B701, the limitations on impurities for "Fluosilicate" and "Other" would not apply.)

* Based on the chemical equation:

$$K_2SiF_6 + 4NaOH = 2KF + 4NaF + H_4SiO_4$$

from which 1 ml 0.2*N* NaOH is equivalent to 0.0094 g Na_2SiF_6.



Percolation and Runoff

10,000 on the nose was AWWA's membership as of July 1—and the nose belonged to Ferd M. Merritt, Supt., Water Dept., Chadron, Neb., whose application arrived just in time last June to turn up all the zeros. Not Mr. Zero, though, Ferd's going to be known from now on as Mr. 10,000 or, to us who know him better, Special Merritt (see photo p. 76 P&R).

All of this means, of course, that if every member were to sign up just one new member between now and March 29, 1956, AWWA would reach its 75th birthday 20,000 strong. Too much to ask? Nonsense! Certainly no less than everyone will share the burden. And the By-Laws don't permit of half-members. Quite confidentially, though, we'd settle out of print for an even 12,000 by that date—just 500 times as many, that is, as the membership in 1881.

Onward and upward goes AWWA—its merits attracting its Merritts.

Crocodile tears, not really intended to help slake the thirst of "drought-stricken" residents of metropolitan New York and northern New Jersey, were shed by our Communist cousins in the Soviet magazine *New Times* as long ago as last May. The poor capitalistic souls, was the melancholy Malenkovy report, are not even able to operate their fine new washing machines because their shining nickel faucets "snort, wheeze, and squirt" but provide no water. Next thing you know, they'll be spreading the rumor that our unskilled laborers can't even get good stewards for their yachts.

Meanwhile, even crocodile tears wouldn't be sneered at by the water works men supplying the "poor souls," for precipitation during the first six months of 1954 was 7 in. below normal in the New York–New Jersey metropolitan area, and though the water supply situation in most areas isn't yet critical, it has been dry enough to kill off a lot of maples, planes, evergreens, and other trees, and to threaten all short-rooted vegetation that can't be irrigated.

The obvious answer to the water shortage, if it does come, will be to melt down not only the washing machines but the inside plumbing to make weapons to protect us against Communism. We'll just bet that our glorious customers would then, even without our asking, reduce their water consumption for the good of the Cause. Else, of course, we could always reduce our glorious customers!

New Times, indeed!

(Continued on page 34 P&R)

(Continued from page 33 P&R)

Greetings from Ike are beginning to be broadcast too indiscriminately to suit the watchdogs of our scientific manpower. What, they wonder, has happened to the "Selective" in our Selective Service System, when more and more of the "relatively small number of specialized personnel within the military age group whose intellectual attainments and technical training make them vitally necessary to the advancement of science and engineering" are being called into the military? This drift toward universal military training has been cited as particularly dangerous in view of the fact that our potential enemies, who far outnumber us, have been rapidly closing the technological gap gained for us by past scientific achievements, thus making it vitally important for us to utilize to the maximum the limited scientific and engineering manpower available. It is the suggestion of EJC's Engineering Manpower Commission that "we reject universal military service as a basic concept and return to the principle of selection, under which men are selected for deferment by reason of their occupation and its importance to national welfare, or selected for induction because their service in uniform is deemed more important than their civilian work."

The reduction of II–A occupational deferments, from 30,000 at the end of January 1953 to about 18,000 by the end of last May, has undoubtedly been the result of applying the principle of equality of sacrifice—a principle that cannot help but loom large in the minds of members of local selective service boards in dealing with their neighbors' children or, for that matter, in considering the importance of scientific specialties which they are not qualified to judge. It isn't easy to explain to the Jones's why the Smith's Johnny, "who's already drawing much more pay than a boy of his age could possibly earn," should be allowed to continue his good job at the chemical plant, while their Billy must give up his soft drink business to carry a gun. The only answer, of course, is that the concept of equality of sacrifice must yield to the basic security needs of the nation. But that doesn't sell too well on a person-to-person basis. Besides, it means that our potential enemies have done us out of still one more of our precious principles.

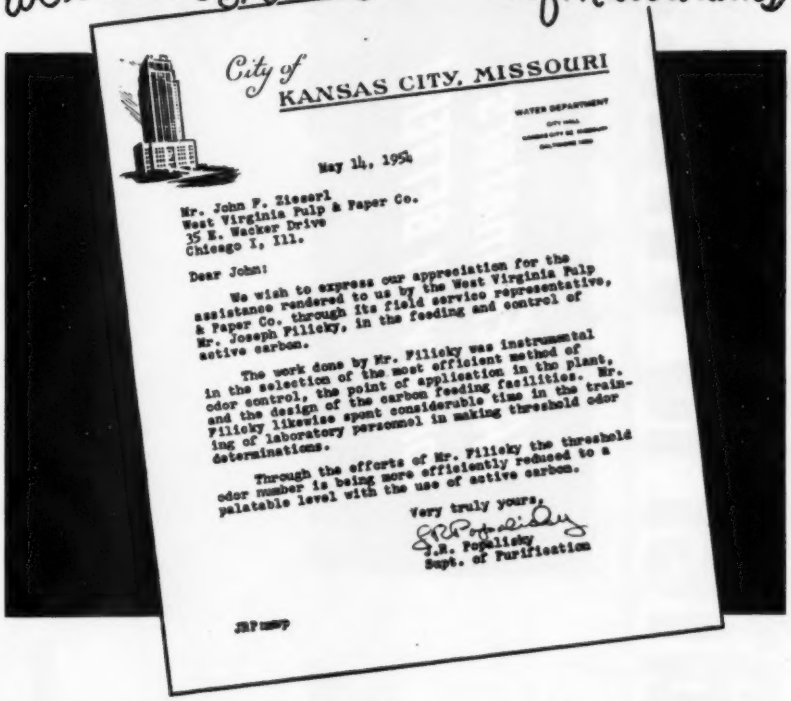
The tightened deferment picture as well as the onus of being a slacker have had their indirect effects, too, toward the same end of universalizing military service. Either because they expect to be caught sooner or later anyway and want to get it over with, or because they resent the imputation that they lack patriotism, many of the Johnny Smiths are volunteering for military service. And there, because they have the technical qualifications, our engineers and scientists are becoming officers, thus tying themselves up for extended periods in the reserve, subject to immediate call when they will be most needed in their civilian pursuits.

One suggestion for helping to equalize the sacrifice while maintaining the advantages of the selective system and giving the person who is deferred an opportunity to discharge his obligation to the nation has been advanced by Howard S. Corey, a member of the American Chemical Society, in the form of a suggested amendment to the present selective service law. It is his idea that compulsory service should be

(Continued on page 38 P&R)

THANK YOU, KANSAS CITY!

we like the "show me" attitude of Missourians



City of KANSAS CITY, MISSOURI

WATER DEPARTMENT

May 14, 1954

Mr. John P. Ziesorl
West Virginia Pulp & Paper Co.
35 E. Wacker Drive
Chicago 1, Ill.

Dear John:

We wish to express our appreciation for the assistance rendered to us by the West Virginia Pulp & Paper Co. through its field service representative, Mr. Joseph Pilicky, in the feeding and control of active carbon.

The work done by Mr. Pilicky was instrumental in the selection of the most efficient method of odor control, the point of application in the plant, and the design of the carbon feeding facilities. Mr. Pilicky likewise spent considerable time in the training of laboratory personnel in making threshold odor determinations.

Through the efforts of Mr. Pilicky the threshold odor number is being more efficiently reduced to a palatable level with the use of active carbon.

Very truly yours,

J.R. Popelisky
Supt. of Purification

JRP:mmp

Showing water plant operators the most advantageous method of using Aqua Nuchar activated carbon is an important function of our technical staff. INDUSTRIAL'S Threshold Odor Specialists will, *without obligation*, make a complete taste and odor survey of your plant; assist operators in the techniques of running Threshold Odor Tests; and advise as to the most efficient amount of Aqua Nuchar needed and as to the most effective point of application. Also as a part of their regular service, they will check the influences of other chemicals used in your water treatment and recommend how Aqua Nuchar activated carbon may best be used in conjunction with them.

The use of Aqua Nuchar activated carbon provides palatable and odor-free water at an extremely low cost per capita. If you do not now use Aqua Nuchar investigate its adsorptive power to deliver sparkling, palatable water. If you use Aqua Nuchar and wish to be shown how and where it should be applied to do the most efficient job on your threshold odor number, contact the nearest INDUSTRIAL office, now.

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Water is vital...
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THE cropless wastes of once-fertile land have proved it again . . . water makes the difference between food and famine! Today, thousands of farmers and ranchers must haul water from nearby towns. With water supplies so low, Badger meters are almost as vital as the water itself. They provide a precise check on usage and waste . . . assure a fair allotment of the water available . . . and help water departments get a fair price for water and service. As a result, Badger meters even help keep waterworks self-supporting for thousands of communities. And they operate dependably, economically, with a minimum of servicing.

BADGER Water Meters

BADGER METER MFG. CO.
Milwaukee 10, Wisconsin

"Measures the water of the world"

(*Continued from page 34 P&R*)

exacted of all those receiving academic deferments following completion of their academic work, but that this service be in research or other civilian endeavor in line with their scientific education and training. Although making such service of the same duration as the prevailing military hitch and paying the scientist at military pay rates would indeed be a step toward equalization, its administration would involve a most unwieldy and expensive procedure for handling the 1 per cent of draftees that would be in the group. And since no program that would keep scientists at their science could really be compared with that of making killers of most of the remaining 99 per cent, the gesture hardly seems worth the effort.

Perhaps the only really equitable way would be to draft everyone and everything and put every component of our economy to work where it would do the most good for the common cause—rather Hitlerian, of course, and perhaps just a mite socialistic, but undoubtedly efficient. Whatever the system Congress might adopt there are bound to be inequalities. Whatever the system, the more insufferable among our young scientific geniuses are bound to arouse resentment among the parents of men in military service. But it remains a fact that it would be most unintelligent to waste our valuable engineering and scientific talent in the ranks when it is needed desperately in the industrial production and research that support the ranks.

Whatever the system, too, it is unlikely to be of very great assistance to water works men in their travail. During the last war, certain classifications of highly trained water works men were entitled to deferment, but only a few chemists and sanitary engineers responsible for the safety of public supplies had attained these responsible positions while they were still of draft age. More troublesome than military service was the loss of trained personnel to better-paying positions in war industry and the competition with war industry for even the relatively unskilled workers. At any rate, since their problems are bound to be aggravated next war by some close contact with the shooting, water works men will do well now to begin training their own army from among Ike's ungreetable.

Paul D. Haney, sanitary engineer director of the Public Health Service's Sanitary Engineering Center, has joined the Kansas City, Mo., consulting firm of Black & Veatch.

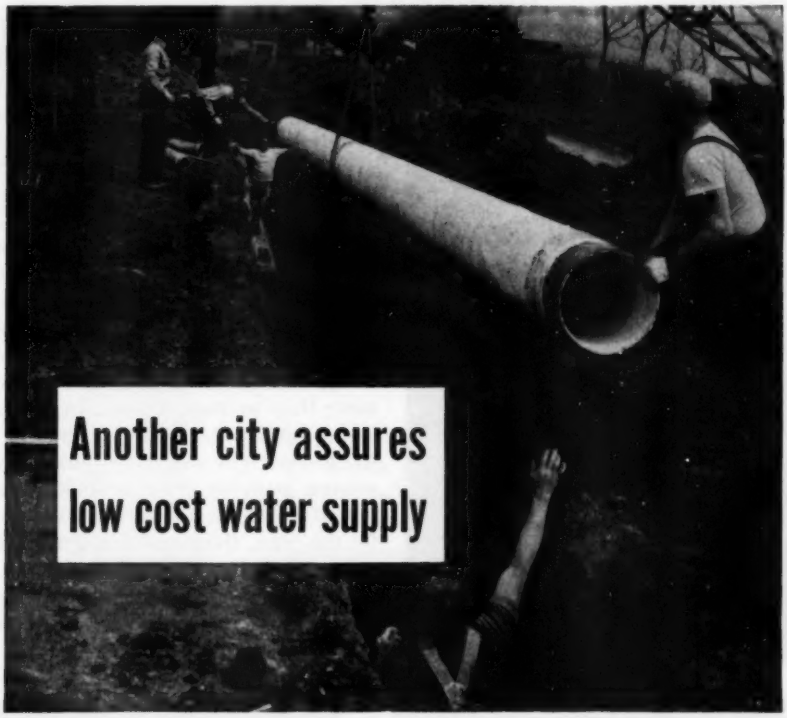
(*Continued on page 40 P&R*)

DESIGNER-ESTIMATOR WATER CONDITIONING

Water Conditioning Designer-Estimator desired by client of this agency. Attractive salary, bonus, pension, paid vacations. Located in suburbs of large eastern city in small town. Prefer engineering degree with some water treatment experience. Address confidential inquiries with photograph to Walter S. Chittick Advertising Agency, 1500 Walnut Street, Philadelphia 2, Pa.

OFFICE SALESMAN WATER CONDITIONING

Water Conditioning office salesman desired by an important client of this agency. Attractive salary, bonus, pension, paid vacations. Friendly working conditions. Eastern location. Small suburban town near large city. Prefer college education; some water treatment experience. Address confidential inquiries to Walter S. Chittick Advertising Agency, 1500 Walnut Street, Philadelphia 2, Pa.



This midwestern city saved money two ways with Armco Welded Steel Water Pipe. First: Long, easily handled lengths helped speed installation and assured low initial cost. Second: Spun-enamel lining prevents tuberculation and provides *continued* high flow capacity.

Also important, Armco Steel Pipe is available in a wide range of diameters and wall thicknesses, making it easy to specify exactly the pipe you need. Ample strength and ductility withstand pressure surges and heavy external loads without damage.

Whenever you're planning new water supply lines or force mains, help your city to lower costs with Armco Welded Steel Pipe. For complete data, write Armco Drainage & Metal Products, Inc., Welded Pipe Sales Division, 1644 Curtis Street, Middletown, Ohio. Subsidiary of Armco Steel Corporation. In Canada: write Guelph, Ontario.

ARMCO WELDED STEEL PIPE

ARMCO

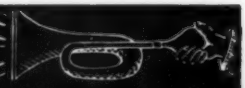
Meets A.W.W.A. Specifications

(Continued from page 38 P&R)

Kodiak kodaks were really klicking at the Seattle convention's Klondike Kickup, catching crowds of water workers at some of their most conscientious concentrating of the week —on advanced statistics, that is. Behind the mustache at the left, giving his views on standard deviation to AWWA Secy Harry Jordan, is Clare Parks, the Klondike Kount who was in charge of organizing and operating the affair. At the lower left, meanwhile, at least Lauren Grayson, John Pray, and Chris Medbery are showing more than average interest in the galloping dominoes; while everyone at the lower right seems too busy determining probable error to look up and identify himself. Front and center, by the way, those are not graduation robes that Reg "Happy" Hayes is wearing, but the costume that won him first prize. And next year we'll expect him to fire up Chicago as Mrs. O'Leary's cow!

(Continued on page 42 P&R)

YOU WERE DOING THIS



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HYDRO-TITE

(POWDER)

For over 40 years HYDRO-TITE has been faithfully serving water works men everywhere. Self-caulking, self-sealing, easy-to-use. Costs about 1/5 as much as lead joints. Packed in 100 lb. moisture-proof bags.

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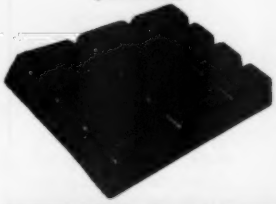


HYDRO-TITE

(LITTLEPIGS)

The same dependable compound in solid form —packed in 50 lb. cartons—2 litters of pigs to the box—24 easy-to-handle Littlepigs. Easier to ship, handle and store.

FIBREX (REELS)

FIBREX

(REELS)

The sanitary, bacteria-free joint packing. Easier to use than jute and costs about half as much. Insures sterile mains and tight joints.

HYDRO-TITE

HYDRAULIC DEVELOPMENT CORPORATION

(Continued from page 40 P&R)

Radiological health training programs sponsored by the US Public Health Service at its Sanitary Engineering Center, Cincinnati, include the following:

Nov. 1–5, 1954, and May 16–20, 1955: Problems of Radioactivity in Water Works.

Jan. 10–21 and Apr. 18–19, 1955: Basic Course in Radiological Health.

May 2–13, 1955: Environmental Radiation Sanitation.

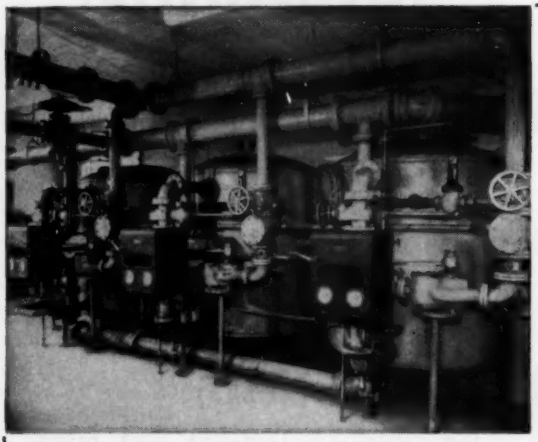
Further details may be obtained from the Chief, Radiological Health Training Sec., Robert A. Taft Sanitary Engineering Center, 4676 Columbia Pkwy., Cincinnati 26, Ohio.

A water plant safety symposium will highlight the public and water utilities sessions at the National Safety Congress to be held at the Conrad Hilton Hotel, Chicago, during the week of October 18, 1954. Of greatest interest to water utility workers will be the sessions on October 19–21, during which speakers will show how the poor accident rate of water utilities can be improved. Safety, as they say, is no accident.

Neptune Meter Co. has moved its executive and general sales offices to larger quarters at 19 W. 50th St., New York, N.Y.

Vincent deP. Lukas has been appointed sanitary engineer for the General Electric Co., assigned to a company-wide project on water supplies and waste treatment, under the general direction of Kenneth S. Watson.

(Continued on page 44 P&R)



WATER PROBLEM?

Photo on left shows a typical H & T fully automatic, municipal, zeolite water softening plant producing clear, iron free, soft water.

Operation of this automatic water treatment plant is by our electrically operated *poppet* type multiport valves—the valves which provide unequalled performance.

If you have a water problem of any size or type—write us. With over 50 years of experience—conditioning water—We Can Help You

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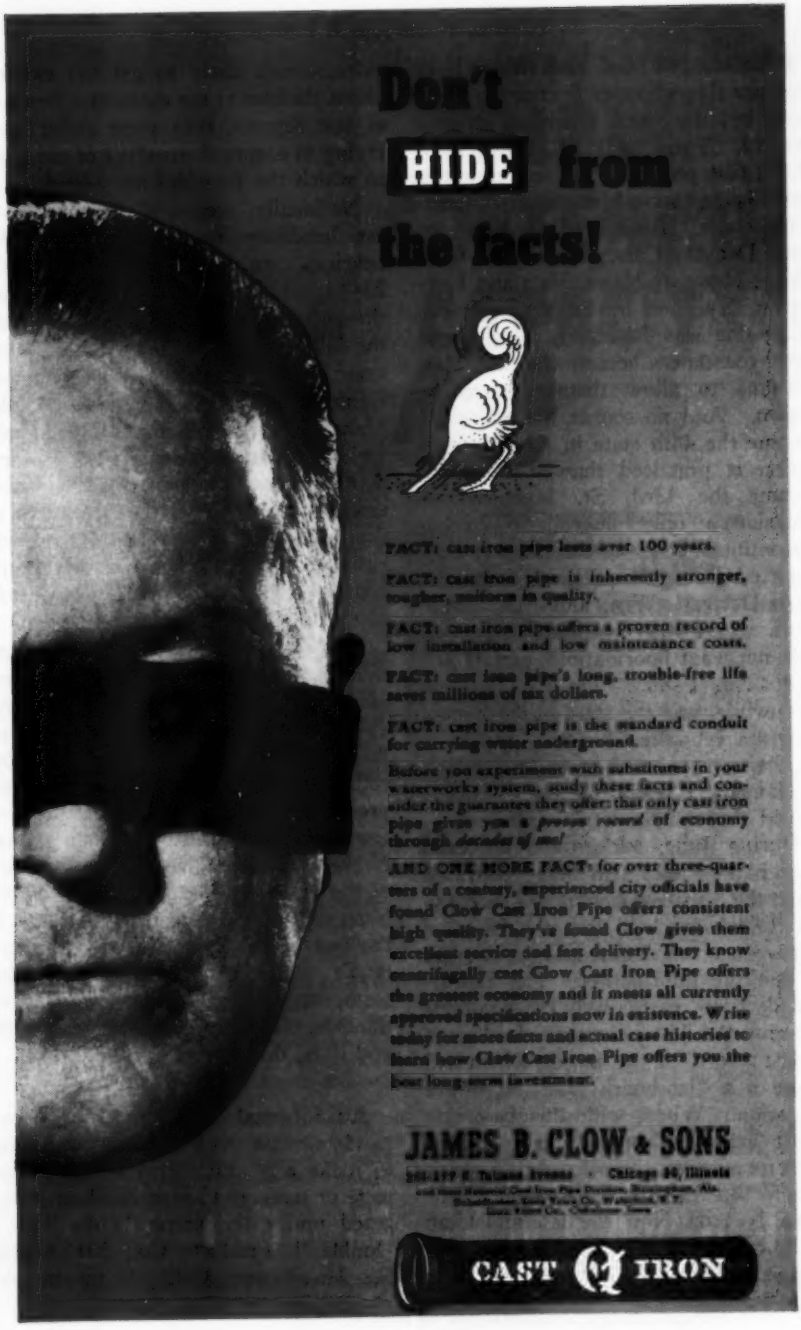
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FACT: cast iron pipe lasts over 100 years.
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CAST IRON

(*Continued from page 42 P&R*)

Fluoridation ins and outs have kept our fluoridimeter fluctuating these days, but the trend continues sharply upward. Thus, by June 30 a total of 17,601,658 people in 981 communities were being served artificially fluoridated water. Biggest of the latest ins were Denver, Colo.; Oklahoma City, Okla.; Newport News, Va.; and Lexington, Ky.; but by far the most exciting one was Richland, Mo., whose 1,600 consumers became the first Missourians to allow themselves to be shown. And no sooner had Missouri become the 44th state in which fluoridation is practiced than it forthwith became the 43rd, St. Martinville—Louisiana's only fluoridator—having discontinued its program. Other outs reported during the past couple months were Delavan, Wis., and San Diego, Calif., where 46,976 people voted "Yes, I do not want fluoridation" and 41,382 said "No, I do." On the horizon, meanwhile, was the start of the largest program yet—the Chicago City Council having voted to initiate fluoridation by January 1, 1955, for the 4,000,000 served through the city's system.

During June, background for even later innings was also being provided when the Supreme Courts of Louisiana and Oklahoma held that the cities of Shreveport and Tulsa had legal right to institute fluoridation. The Louisiana decision, particularly, was notable in being the first judgment of a "court of last resort" on the matter, which will make it a "landmark case" in future litigation. When, with this favorable court action, Shreveport goes ahead with its program, it will restore Louisiana to the fluorolls, leaving only Arizona, Nevada, New Mexico, and Utah to be caried away. And they, low in population and high in natural fluorides, aren't likely to get too excited about the idea at the moment. Besides, at last reports, they were awful busy trying to assure themselves of the stuff to which the fluorides are added.

Nationally, meanwhile, rather modest headlines were being made by hearings on the Wier bill (HR 2341), which seeks to ban fluoridation throughout the United States. For the bill, and against fluoridation, were three organized groups—the National Committee Against Fluoridation, the Massachusetts Women's Political Club, and the Christian Science Church—and a number of interested individuals; against the bill were representatives of the leading professional health organizations and agencies. Probable outcome of their disagreement is the death of the bill in committee.

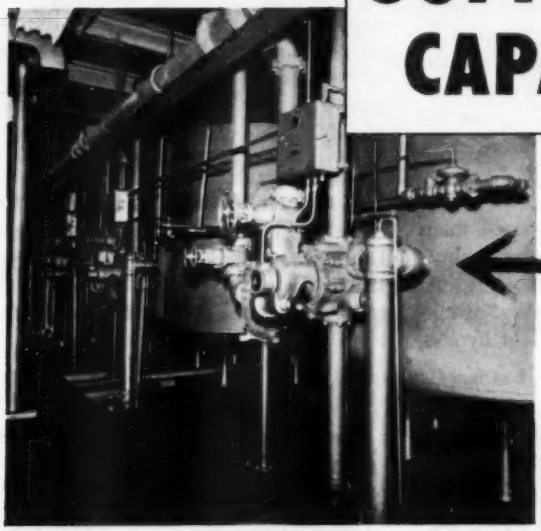
Internationally, too, there is activity to report, with word from New Zealand of a strong Anti-Fluoridation Society fighting a determined battle to prevent the procedure from gaining a foot—or, rather, mouthhold. To date only one project has been undertaken there—a controlled experiment at Hastings and Napier—and that over the dead bodies of the A-FS. One explanation of the bitterness of the opposition, perhaps, is the fact that 73 per cent of New Zealand's adult population wears false teeth, unhelpable by any amount of fluoride. That does get us back to ins and outs, doesn't it?

An internal pipe wrench that expands against the inside wall of tubing to make a positive grip without slippage or damage to pipe has been marketed under the name "Tube Tule." Double T Products Co., 301 Acacia St., Hawthorne, Calif., is the maker.

(*Continued on page 46 P&R*)

How the Town of Normal, Illinois

TRIPLED SOFTENING CAPACITY



...of the same softeners

...by changing to PERMUTIT Q

● Replacing old-fashioned zeolite with the high-capacity ion exchange resin, Permutit Q, saves Normal over $7,000 a year!

Normal's three automatic softeners were installed back in 1946, before high-capacity Permutit Q was available. Each softener removed hardness from 83,000 gallons of water between regenerations for a daily delivery of 700,000 gallons of softened water.

Recently town officials called in Consulting Engineers, Farnsworth and Conley, of Bloomington, Illinois, who recommended replacing zeolite with modern, high-capacity Permutit Q.

Look at the benefits gained from this change! The capacity of each softener is up from 83 to 270 thousand gallons between regenerations. Salt Consumption is down to about ¼ lb. per thousand grains of hardness removed. Flow Rate —up from 285 to 510 gpm. Regenerations are down from 3 times to once per day per softener.

A change to Permutit Q may effect similar economies for your city. We'll gladly send helpful data.

The Permutit Company, Dept. JA-8, 330 West 42nd Street, New York 36, N.Y., or Permutit Company of Canada, Ltd., 6975 Jeanne Mance Street, Montreal.

WATER CONDITIONING HEADQUARTERS FOR OVER 40 YEARS

PERMUTIT®

(Continued from page 44 P&R)

No more pencils, no more books seems somehow synchronized each year with the outbreak of all kinds of water system disturbances. No sooner does school close in such cities as New York and Philadelphia than the hydrants open and summer conservation campaigns go blooey. Reservoirs seem suddenly to get fished in or swum in despite all signs and snares. Then there are a number of nonstandard difficulties: At Newark, N.J., for instance, families in a four-block area were without water when "a boy" dropped a rock in a street excavation breaking a valve on an exposed main to flood the street and require a shutdown of the section for repairs. At Cranford, N.J., last month, "pranksters" blocked a Rahway River bypass, cutting off the water supply of the city of Rahway, seriously weakening a temporary road across the river, and almost toppling a 25-ton crane into the water. And at Cincinnati, "some kids" appropriated their mother's soap boxes and made a bubble bath of Tyler Davidson fountain on Fountain Square, requiring a shutdown and cleanup by city personnel. All this occurred, too, in the first week or two of vacation—just wait till this month, when they begin to be bored. *We might try pens or even hooks!*

A Graver Water Conditioning Co. office has been opened at Copenhagen, Denmark, to handle sales in Western Europe and the Scandinavian countries. Jorgen Berring, sales engineer, is in charge.

(Continued on page 48 P&R)

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and assure FULL REVENUE
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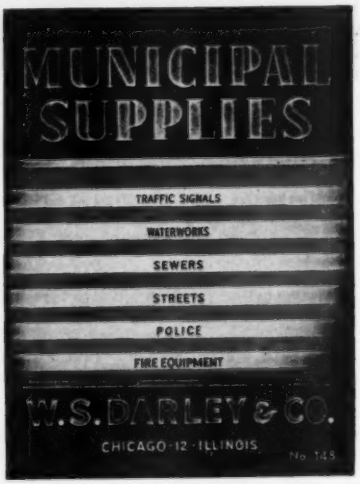

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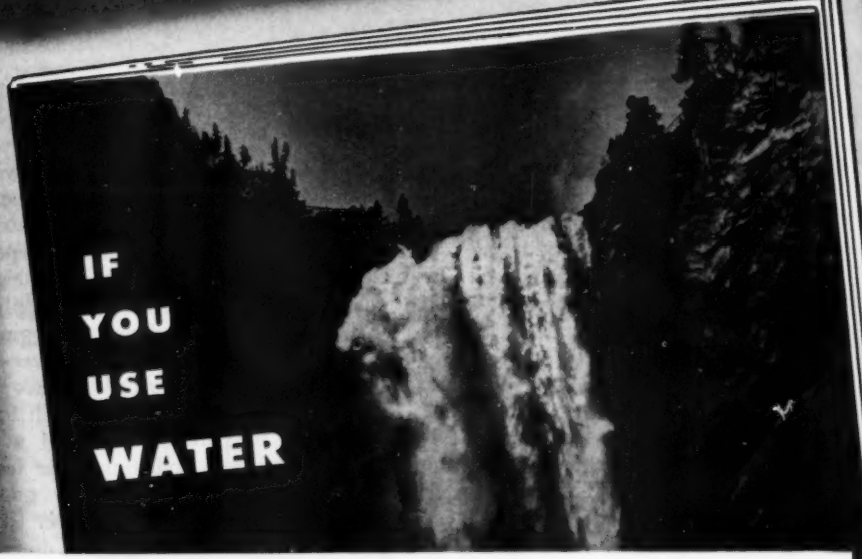

HERE IS AN IMPORTANT NEW BOOK ON WATER TREATMENT WITH AMBERLITE ION EXCHANGE RESINS

"If You Use Water" is a 24-page 1954 publication about the increasingly important subject of water treatment by ion exchange. It's yours without charge, simply by writing and asking for it.

"If You Use Water" discusses the application of the AMBERLITE ion exchange resins to all phases of water treatment, including softening, dealkalization, deionization, and silica removal for boiler feed and other uses. Amply illustrated with flow diagrams, this book points to the solution of a host of water conditioning problems.

Prepared by Rohm & Haas Company ion exchange specialists, "If You Use Water" shows you the way to decreased cost and increased quality of water treatment. In addition, it tells you about the use of the AMBERLITE ion exchange resins in research, medical therapy, air conditioning, television tube manufacture, food processing, printing, electroplating, and other important fields.

Send for your free copy of this booklet today

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AMBERLITE is a trademark, Reg. U.S. Pat. Off. and in other principal countries of the Western Hemisphere.

(*Continued from page 46 P&R*)

Science sometimes can't see the desert for the sand. "Nobody," it claims, "knows where the camel stores its water," so, without further ado, a group of researchers, financed by UNESCO's Advisory Committee on Arid Zone Research, started looking into the matter under the direction of Dr. Knut Schmidt-Nielson of Duke University. And what have they found so far? "No convincing evidence that the camel draws on the 'water compartments' of its stomach when it is thirsty." "It loses very little water by excretion." "When it gets a chance, it can drink ten gallons in a few minutes without ill effects." Astounding, isn't it, to labor so hard and fruitlessly when any schoolchild, without a moment's hesitation, could have told them that the secret is in the humps—the camel's elevated storage tank (or is that tanks)? Yes, as a matter of fact, better they should have dedicated themselves to the solution of the problem propounded by our good friend Ogden Nash:

> The camel has a single hump,
> The dromedary, two—
> Or else the other way around.
> I'm never sure, are you?

The zoo's who in the water works field doesn't stop with the camel by any means. As a matter of fact, since his is strictly a private system, he hardly rates the notice given. Who does, though, is the elephant—water supplier not only to his own family but to a host of fellow citizens of the jungle. Discovery of this trunk-line water service was made by Mervyn Cowie, director of the Royal National Parks of Kenya in a tour of the River Tiva to the northwest of Mount Kilimanjaro. As the river dries up for the greater part of the year, Mr. Cowie reported, animals such as the rhinoceros, lion, eland, buffalo, zebra, baboon, monkey, giraffe, and many small species of antelope depend upon the elephant to provide their water supply. Which the elephant does by digging water holes in the bed of the river—"scraping away sand with his trunk to form a slanting hole deep enough for the water to percolate through and form a small pool, sometimes four feet below the surface." Like any good water supplier, the elephant never forgets his customers, though it is doubtful whether they acknowledge his contribution. Better off than most water works men, though, he's pretty well equipped to resist their complaints—big ears to the contrary notwithstanding.

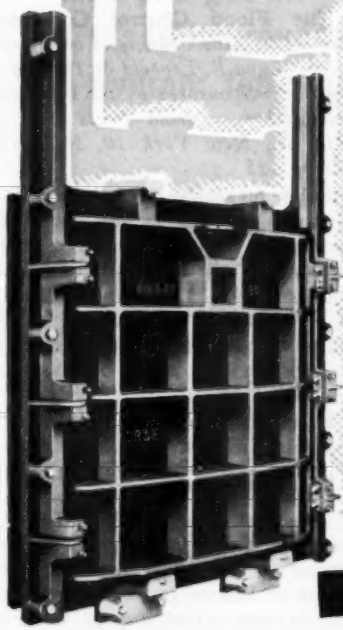
Sergio Cuevas has resigned as executive director of the Puerto Rico Aqueduct & Sewer Authority. He had held that position since the authority was established in 1945 to operate the water and sewage works of the Puerto Rican municipalities, and guided a two-fold increase in safe yield and a more than four-fold increase (from $15 to $69 million) in utility plant. Mr. Cuevas, who will continue to serve the authority as a consultant, is being succeeded by Rafael V. Urrutia.

William E. Borbonus has been elected president, and Kenneth K. Kirwan vice-president and chief engineer, of the Centriline Corp. of New York. James P. Cummins, the previous president, returns to the parent organization, the Raymond Concrete Pile Co.

F. A. Fiesler has been appointed superintendent of the Water Dept. at Edwardsville, Ill.

(*Continued on page 82 P&R*)

Pekrul *Grows*



To keep pace with the ever increasing demand for PEKRUL GATES over half a century, MORSE BROS. MACHINERY has just completed an extensive modernization program. The installation of many new machines and facilities, an increased engineering staff, and complete, new, custom re-tooling specifically for PEKRUL GATE production means...

modern design and superior engineering service...

even faster PEKRUL GATE deliveries to you...

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Flood Control Sewage Disposal Rearing Ponds Recreation Pools
Levees Reservoirs Irrigation Cooling Towers Pumping Plants
Water Works Oil Refineries Steel Mills Dams Fish Hatcheries

The Reading Meter

Basic Hydraulics. *Navpapers 16193. Standards & Curriculum Div., Training Bureau of Naval Personnel. (1945; 1951) 314 pp.; paperbound; $1.25 from Government Printing Office, Washington 25, D.C.*

This Navy training manual deserves mention in these pages, despite the length of time it has already been in print, because it is probably little known outside of the services and yet provides an excellent introduction to elementary hydraulics and hydraulic equipment—including pipes, fittings, valves, and pumps. The text is clear and simple, and the illustrations—many of them in two colors—are lucid and helpful. Decidedly useful for the ambitious operator—or anyone without an engineering background.

Handbook of Hydraulics. *Horace Williams King; rev. Ernest F. Brater. McGraw-Hill Book Co., New York (4th ed., 1954) 563 pp.; $8*

This fourth edition of an old standard has been revised and brought up to date, but the avowed intent is still what it was when the first edition appeared in 1918: to secure accuracy and to simplify calculations. Towards this end a large portion of the book is devoted to tables that are useful in the solving of the various hydraulic formulas discussed by the text. A convenient and practical reference work.

Simplified Water Supply Testing for Fire Departments and Insurance Engineers. *Federation of Mutual Fire Insurance Companies, 20 N. Wacker Dr., Chicago 6, Ill. (1953) 24 pp.; paperbound; free*

A detailed procedure for making fire flow tests of water systems, this booklet is written in simple, direct terms. The value of the tests, equipment to use, principles involved, and appropriate procedures are explained; and calculations and interpretations discussed.

The Flood Control Controversy: *Big dams, little dams, and land management. Luna B. Leopold & Thomas Maddock Jr. Sponsored by the Conservation Foundation. Ronald Press Co., 15 E. 26th St., New York 10, N.Y. (1954) 278 pp.; $5*

Calm and reason characterize this Conservation Foundation study, and at the very outset the authors make it clear that "floods . . . are characteristic of rivers" and their complete prevention is not possible. Instead, "we must buy our floodplain occupancy at a price, and the price depends on the degree of flood control desired."

From this base the authors proceed to examine the upstream-downstream control controversy that is being waged in the field by the Soil Conservation Service of the Dept. of Agriculture (upstream) and the Corps of Engineers (downstream). They level criticism at the Corps of Engineers for being interested only in construction projects, while ignoring an administrative approach like floodplain zoning. On the other hand, they tend to support the Corps by pointing out that the downstream approach tends to provide protection where it is most needed, whereas soil conservation measures alone have little effect on widespread storms. Even in combination with up-

(*Continued on page 52 P&R*)

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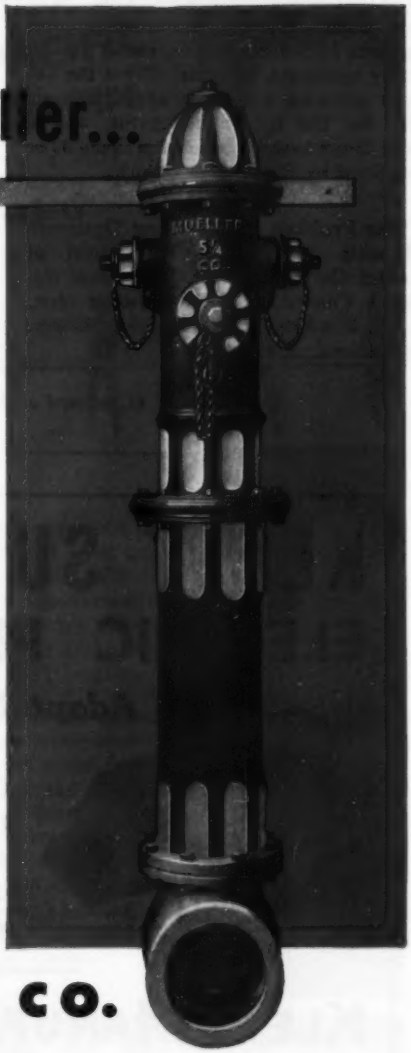

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The Reading Meter

(Continued from page 50 P&R)

stream detention and other structures, the upstream approach has its limitations, and is not a cure-all, although its benefits to agriculture are unquestionable.

As usual, the complexity of the problem suggests an administrative, rather than a purely hydraulic, solution. What the authors advocate are more adequate basic data for the upstream regions, and a more direct assessment of cost upon those benefitted by flood control works.

The Problem of Providing Optimum Fluoride Intake for Prevention of Dental Caries. *Pub. 294, National Research Council, 2101 Constitution Ave., N.W., Washington, D.C. (1953) 15 pp.; paperbound; 50¢*

This pamphlet is a report of the Committee on Dental Health of the National Research Council's Food and Nutrition Board. It considers the possible alternatives to the public water supply as a fluoride-bearing medium; sugar, salt, milk, and fluoride tablets are among the possibilities considered and, after examination, discarded. They still prefer water.

Water Fluoridation. *Report of the Committee of the St. Louis Medical Society, 3839 Lindell Blvd., St. Louis 8, Mo. (1954) 14 pp.; paperbound; 75¢*

This carefully documented report, reprinted from the February 1954 issue of *Missouri Medicine*, was "designed to be fully intelligible to laymen in study groups

(Continued on page 54 P&R)

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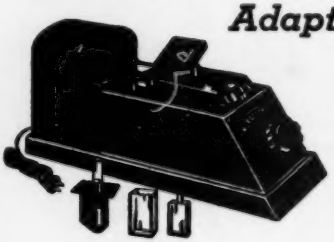

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(Continued from page 52 P&R)

and legislative bodies as well as to give a comprehensive understanding of the subject to dentists and physicians." And it is successful in achieving its goal, although neither in content nor in appearance could it be said to utilize a "popular" approach.

After reviewing the evidence which determined the committee unanimously to recommend fluoridation for St. Louis, the report gives minute attention to the arguments of the opposition. The exploded cancer scare at the University of Texas is reviewed; the allegations of danger to health, to industrial processes, and even to national security are examined with curiosity and carefully dismissed; and some notoriously shameless bits of doctored evidence are exposed. Some few respectable arguments by reputable investigators are also examined with polite respect, but the committee's conviction remains unshaken.

Municipal Index—1954. *American City Magazine Corp., 470 Fourth Ave., New York 16, N.Y. (1954) 1,023 pp. (including advertising); $5*

This is the 28th edition of this annual purchasing guide for municipal officials. It includes a roster of town and country managers and a listing of department heads (including water and sewage works superintendents) in cities of more than 10,000 population. As usual, an atlas of 128 pages has been bound into the volume to furnish maps and 1950 population statistics.

The Municipal Year Book: 1954. *Clarence E. Ridley & Orin F. Nolting, ed. International City Managers' Assn., 1313 E. 60th St., Chicago (1954) 613 pp.; thumb-indexed; $10*

The latest edition of this municipal reference book contains new material on fringe-area problems and services, and also sewage service charges. A tabulation of cities of 5,000 and over population lists whether they operate water utilities or water distribution systems, but the bulk of the book's wealth of data is concerned with general municipal functions and services.

How to Dowse: *Experimental and Practical Radiesthesia. Marguerite Maury. G. Bell & Sons, Ltd., London (1953) 184 pp.; $2.65 from British Book Centre, 122 E. 55th St., New York 22, N.Y.*

Dowsing is radiesthetized, if not entirely enscientificated, in Mme. Maury's methodic manual. Gone is the twig and that "psychical something or other" which made it twitch, replaced by the pendulum or rod with appropriate amplification apparatus and the "purely physical" still "something or other" that permits its users to detect not only water, but minerals, oil, diamonds, coal, the growing characteristics of soil, the breeding potentialities of animals, the sex of embryos, as well as the various diseases of mankind and the proper therapeutic techniques for their cure. Even the word "dowsing" is eschewed once it has served its commercial purpose in the title, and "radiesthesia" rules supreme as a "science" whose essential characteristics are "its variability, its uncertainty, and its individual quality."

So lousy with science has this former "art" become that it will take more than mere engineers to cope successfully with such difficulties as "remanence, parasitic images, telluric emissions, aberrations of syntonisation," and all the other complexities of pendular detection. As a matter of fact, unless Madame's 21 lessons are much simpler in French [which our D— in French III permits us to doubt], we can't quite see why the 900 correspondence course enrollees of her

(Continued on page 78 P&R)

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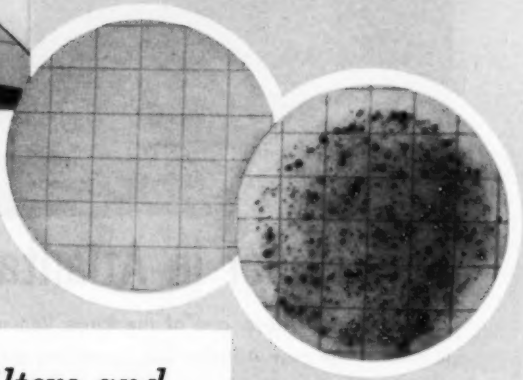

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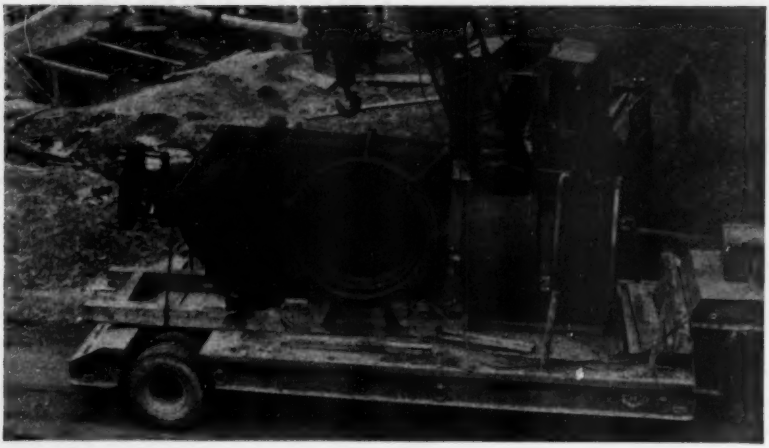

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Key: In the reference to the publication in which the abstracted article appears, **39**:473 (**May '47**) indicates volume 39, page 473, issue dated May 1947. If the publication is paged by the issue, **39**:5:1 (May '47) indicates volume 39, number 5, page 1, issue dated May 1947. Abbreviations following an abstract indicate that it was taken, by permission, from one of the following periodicals: *BH—Bulletin of Hygiene (Great Britain); CA—Chemical Abstracts; Corr.—Corrosion; IM—Institute of Metals (Great Britain); PHEA—Public Health Engineering Abstracts; SIW—Sewage and Industrial Wastes; WPA—Water Pollution Abstracts (Great Britain).*

FOREIGN WATER SUPPLIES—GENERAL

The Water Supply of Cambridge [Gt. Br.]. T. C. NICHOLAS. Wtr. & Wtr. Eng. (Br.), **57**:318 ('53). Medieval Cambridge obtained its water partly from wells, partly from river, and partly from artificial channel known as "King's Ditch." First steps to supply pure water from outside town were taken in 1325 by Franciscans or Gray Friars. In 1574, upon outbreak of plague, it was written: "our synnes is the principal cause; the other, as I conjecture, is the corruption of the King's Dytch." In 1850 bill was promoted in Parliament for incorporation of "Cambridge Water Works Co.," which proposed to take water from Hobson's Brook. Rival scheme appeared and in 1852 "Cambridge Waterworks Co." was established to take water from River Cam. Present company was incorporated in 1853. Original works consisted of well 48′ deep, pumping machinery, covered 1-mil gal (Imp.) service reservoir, and 26 mi of 5″–12″ cast-iron mains. About 1883 additional supplies were obtained from large spring, Poors Well, which issues from Lower Chalk 5 miles east of Cambridge. In 1898 company instituted daily bacteriological examination of water. In 1910 application to Parliament for powers to disinfect, either by chlorine or ozone, was at first denied, then granted in Dec. In 1935 company became first in England to install water softening voluntarily and without increase in rates. Water from well has 16° of hardness, which is reduced to 9° before being passed into supply. Plant consists of 8 cylindrical softeners in which water has hardness totally removed by base-exchange process. Resulting water is mixed with unsoftened water to produce blend with 9° of hardness. Minor repair service inaugurated in 1931 is rewashering of taps free of charge. Number so serviced is now about 15,000 annually. Company pioneered in waste prevention; in 1884 it instituted house-to-house inspection of fittings. In 1937 fittings testing department was opened, where all apparatus intended for company use is tested under hydraulic pressure.—*H. E. Babbitt*

The River Severn Scheme of the City of Coventry [Gt. Br.] Water Undertaking. ANON. Wtr. & Wtr. Eng., **57**:223 ('53). Following list of costs illustrates magnitude of scheme: river intake, £46,000; Strensham Waterworks, £334,000; pumping plant, £57,000; treatment plant, £88,000; pipeline, £980,000; and reservoirs, £205,000. Output of water is 6 mgd (Imp.), utilizing 1¾ tons of chemicals. Three pumps lift water from intake well and deliver it to Strensham treatment works, where it is treated with alum and passes upward through vertical-flow sedimentation basins. It then flows to rapid sand filters. Provision has been made for prechlorination of raw water. Chemical feeding is automatically controlled by overflow weirs. There are 6 rapid sand filter beds, each with area of 459 sq ft. Each filter outlet is controlled by a rate controller. During 10–20 min after starting new run, rate of filtering is accelerated to maximum by controller. Filters are washed automatically by electrically controlled sequence of processes. Central switch makes it possible for sequencer to wash filters automatically in order in which they present themselves for washing, or for filters to be selected manually for automatic washing, or for complete washing of filter to be carried out manually. Multipen chart recorder is provided in conjunction with sequencer to give record of time filter was washed. Chlorine, delivered in 16–17-cwt drums, is kept in external drum store in quantity sufficient to meet conditions. 4 chlorinators have been installed in first stage, with provision for feeding into raw water. 2 sulfonators are provided for dechlorinating. Contact tank

(*Continued on page 64*)

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(*Continued from page 62*)

has capacity of 1 mil gal (Imp.). Sludge from sedimentation tanks and filter washing passes to settling tanks from which supernatant water is drawn off and led to River Avon. Three main pumps have been installed, any two of which will deliver 6 mgd (Imp.) to Bredon Res., from which water flows by gravity through 27″ pipeline to Meriden Res. High delivery pressure made it more reasonable to use surge suppressor valve than air release.—*H. E. Babbitt*

Works of the West Hampshire [Gt. Br.] Water Company. ANON. Wtr. & Wtr. Eng. (Br.), **57**:179 ('53). Water supply is taken from River Avon, pumping station and filter beds being situated on bank of river. Low-lift pumping station has ultimate capacity of 10 mgd (Imp.) with 6 electrically driven centrifugal pumps. Hydraulic turbine station at Christchurch contains one low-lift hydraulic turbine driving low-pressure reciprocating pump, lifting raw water from well into small tank from which water gravitates through roughing filters to sand filters. 3 other turbines drive 3 high-lift reciprocating pumps which lift purified water into tower for distribution. Capacity of high-lift pumps is approx. 1 mgd (Imp.). 6 steel Candy filters, each 20′ in diam., were used as roughing filters. This plant now being replaced by 9 small slow sand filters. Filtration area is now 1¼ acres. Chlorination was introduced in 1912 and ammonia in 1920. Final supply is pumped to 2-mil gal (Imp.) covered reservoir, constructed at cost of £48,000.—*H. E. Babbitt*

City of Edinburgh [Gt. Br.] Water Department Regional Scheme for the County of Midlothian. ANON. Wtr. & Wtr. Eng. (Br.), **57**:265 ('53). This £520,000 scheme is designed to meet present and future requirements of Lothian coalfield, housing developments, and agricultural needs of area. It includes microstraining and slow sand filtration plant, 3 service reservoirs, and 2 trunk mains. Filters, with planned capacity of 3 mgd (Imp.), are preceded by two 7′ 6″-diam. microstrainers. There are 5 filters, each 60′ × 100′, and clear-water tank of 2-mil gal (Imp.) capacity. Microstrainers consist of stainless-steel fabric with 80,000 apertures per square inch. Such preliminary filtering increases length of runs. Wash water from microstraining drums and waste water from sand-washing plant discharge into Rosebery Res. Distribution is through 2 principal mains, varying in size from 27″ to 12″.—*H. E. Babbitt*

The Raising of Sennar Reservoir [Sudan] Level. I. HUTCHISON. Wtr. & Wtr. Eng. (Br.), **57**:309 ('53). Sennar Res., located on Blue Nile about 200 mi south of Khartoum, is 1.88 mi long and impounds 206 bil gal. It was proposed to raise full reservoir level by 1 m. Work consisted of: [1] new earth-clay banks upstream from core-walls on east and west banks of river; [2] granite-rubble protection for new upstream core wall banks; [3] 1,280-m earth-clay levee to protect Sennar Town; [4] protection of Sennar Town bank with granite-rubble beaching; [5] constructing 6-m wide drainage outlet through Sennar Town bank; [6] increasing downstream width of existing core wall banks and protecting top of sloping face with red Laterite conglomerate; [7] various smaller works, including improvements to existing rubble drains and reversing surface drainage of railway on top of these banks; and [8] widening inlet channel to main canal. Because existing core walls leaked, it was decided to construct earth fill bank on upstream face of masonry core, protected on sloping face by dry rubble beaching founded on rubble toe, and on top by dry rubble pitching. Sennar Town bank consists of earth 7.20 m wide on top with 2:1 slope and top surface graded 1:20 toward landward face. Water face is protected by rubble beaching similar to that of core wall banks; toe of beaching is 1 m deep and only 1 m wide at bottom. Upstream bank of inlet channel to main canal prevents driftwood from being washed into main-canal gates. Inlet channel was designed to pass 6,000 cfs with water slope of 14 cm/km. Avg output per earth-moving machine was 250 cu m/day in Sennar Town bank, and output per mason on building beaching averaged 4 cu m/day. It has been estimated that final cost of work will be about £210,000.—*H. E. Babbitt*

POLLUTION CONTROL

Problems Involved in Stream Pollution. D. R. STANLEY. Munic. Util. (Can.), **91**:10:36 (Oct. '53). General discussion, with particular reference to stream standards and

(*Continued on page 66*)

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(*Continued from page 64*)

equitable allocation of waste disposal capac. of stream between communities and industries. Term pollution is relative and depends upon stream use. In setting up standards, usual practice to classify stream on basis of use first. Fundamental research on effects of pollution needed. For example, no basic information available regarding safe max. coliform-organism concn. for water used for bathing. Present stream standards largely arbitrary. When standards adopted, common practice is to establish min. effluent standards and det. degree of addnl. waste treatment necessary to maintain stream water in desired condition. Burden of treatment must then be distributed among industries and communities involved. One method is to require each to reduce pollutants by same percentage as detd. necessary for overall situation. Some, however, believe that other factors should receive consideration: vol. of waste discharged, no. of employees, value of industry's property, etc. Weighting of such factors always more subject to criticism than arbitrary percentage reduction basis. Possibly, most economical soln. would be to pool money that would have to be spent by industries and then det. where max. results are obtainable for that expenditure; for example, it might be more economical to treat waste from one industry completely and allow other wastes to be discharged untreated.—*R. E. Thompson*

New Approach to Pollution Control as Developed in Manitoba. L. A. KAY. Munic. Util. (Can.), **92**:2:23 (Feb. '54). In Manitoba, pollution control vested in Provincial Sanitary Control Com., operating under Pollution of Waters Prevention Act. This is in addn. to statutory regulations of Public Health Act. Realized that enforcement of prohibitory regulations generally lax, that stream pollution to some degree is economic necessity, and that even heavily contamd. water can be rendered safe for consumption by modern purif. processes. Proposed that pollution problem be reexamd. Appears essential to divide responsibility on twofold basis of protection of public health and control of valuable natural resource. Policy being considered includes continuing river surveys, establishment of standards for both watercourses and effluents, licensing of outfalls, and grading and zoning of watercourses.—*R. E. Thompson*

The Law Relating to River Pollution Prevention. G. E. WALKER. J. Inst. San. Engrs. (Br.), **52**:105 (Apr. '53). This is review of situation in Great Britain. Subject matter is divided into common law position and statutory prohibition of pollution. Since 1944 three main events have occurred: passing of River Boards Act in 1948, publication of Report of Rivers Pollution Subcommittee in 1949 (so-called Hobday Report) on prevention of river pollution, and coming into force of Rivers (Prevention of Pollution) Act in 1951. Common law position has not changed since 1944 in Great Britain. Author discusses the necessity for pollution prevention, with definitions, and summarizes legislation. Bylaws may be passed prescribing standards for matter to be treated as poisonous, noxious, or polluting by reason of its temperature or its effect in discoloring stream. Storm waters are subject to law in same way as other effluents. As yet no standards have been formulated in general, although recommendations of Royal Commission on Sewage Disposal may be adopted where albuminoid ammonia exceeds 2 ppm; suspended solids, 30 ppm; and dissolved oxygen absorbed in 5 days (BOD test), 20 ppm. Other tests are also applied. Extended discussion is appended.—*PHEA*

Industrial Pollution in the Cleveland, Ohio, Harbor Area. I. Physical and Chemical Results. C. C. DAVIS & H. B. RONEY. Ohio J. Sci., **53**:14 ('53). Preliminary study covering period Sep. '50–Sep. '51. Samples were detd. periodically for DO, total Fe, dissolved Fe, SO_4, turbidity, and plankton, together with field detns. of temp., pH, and Fe at 9 points in harbor and once at 5 locations in Cuyahoga R. Data are reported in tabular form. Most severe pollution was at mouth of river, inside harbor breakwater. This location generally had no DO but high values of temp., SO_4, total Fe, and suspended $Fe(OH)_3$. This area and river upstream provide unfavorable conditions for aquatic life.—*CA*

Planning and Executing a Uniform Pollution Abatement Program for the Kansas River Basin. D. F. METZLER. Proc. ASCE, Sep. No. 303 (Oct. '53). Comprehensive plan for abatement of municipal and

(*Continued on page 68*)

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industrial pollution in Kansas River Basin is described. Emphasis is placed upon development and administration of program. Methods used in developing acceptable pollution abatement policy through public hearings are outlined. Plans for obtaining support for specific bond issues are also recounted. Policy is uniform in that it applies to all polluters, but it is flexible to adjust to special conditions and downstream water uses. 23 new sewage treatment plan s have been built since policy was adopted 31 yr ago, and 27 other cities which lack sewage treatment are in various stages of planning.—*PHEA*

Canadian Experiences in Dealing With Phenolic Wastes. A. D. McRae. Munic. Util. (Can.), **91**:11:51 (Nov. '53). Objectives outlined in '51 report of International Joint Com. on Pollution of Boundary Waters include concn. of phenol or phenol equivs. not exceeding avg of 2 and max. of 5 ppb at any point following initial diln., this being believed attainable if plant effluents contain not more than 20 ppb. Phenol concns. of 1–10 ppm found toxic to fish, and concns. far below toxic limits impart unpleasant flavor to flesh. Chlorophenols usually more toxic than phenols. As little as 0.1 ppb reported to cause taste in chlorinated water, and USPHS standards ('46) specify content of not more than 1 ppb. Methods employed for phenol recovery from wastes include use of solid absorbents, liquid solvents, and volatilization. Residual phenol is destroyed by biol. or chem. oxidn. Sources of phenol in petroleum industry outlined and methods of treatment described, final stage being biol. oxidn., possibly assisted by finishing dosage of Cl or ClO_2. Toxicity of phenolic compds. to bacteria increases with mol. wt. In Dow Chemical Co. biol. oxidn. pilot plant, most prominent organism in oxidn. of phenols was *Achromobacter cruciviae*, which forms slimes in trickling filters and clumps or flocs in activated sludge plants. Protozoa feed on such slimes. Adequate cultures of required bacteria can be prepd. from raw river water or cultivated soil. If NH_3 and NO_3 not present in feed to biol. system, nutrient must be added. Most significant development is recognition by industry that waste treatment necessary part of producn. costs.—*R. E. Thompson*

The Phenolic-Waste Problem in the USA and How It Is Being Handled. N. S. Chamberlin & A. E. Griffin. Munic. Util. (Can.), **91**:11:49 (Nov. '53). Synthetic phenol producn. increased sixfold since '40. Natural phenol (from coal-tar distn.) only 6% of total producn. Chief use in mfre. of plastics. No. of industrial plants contributing to phenol waste problem probably not more than 200–300. Phenol-bearing wastes only 2–3% of discharge from 10,400 industrial outlets. As little as 2 ppb reported to cause taste and odor in water following chln. State water qual. stds. limit phenol compds. in plant effluents to max. of 5–25 ppb, depending upon type of receiving stream. Methods employed for treating phenol wastes include vapor recirculation, liquid extraction, adsorption by bituminous coal or activated C, use for coke quenching, biol. oxidn. after diln. with domestic sewage on trickling filters or by activated sludge process, and chem. oxidn. with O_3, ClO_2, or Cl. Chem. oxidn. too expensive for use except where phenol content naturally low or reduced by other processes such as biol. oxidn.—*R. E. Thompson*

Spent Sulfite Liquor Pollution Abatement Programmes in the Pacific Northwest. H. R. Amberg. Paper Trade J., No. 9, p. 20 ('53). Account is given of methods used in Pacific Northwest for disposal of spent sulfite liquor from manufacture of cellulose. In areas where rain is infrequent, sulfite liquor has been used successfully as road binder. Several mills store spent liquor in lagoons for discharge when adequate dilution by streams is available. Liquors have pH of 2–3, which prevents bacterial action and consequently production of odors but also prevents reduction in BOD and stabilization of waste. Excessive seepage has been considerably reduced by application of cement dust to upper soil. 2 mills at Everett, Wash., previously discharged 73 mgd. of waste waters at surface of Port Gardner Bay, causing gross pollution and reducing concentration of DO to zero for periods during summer, making barrier to migratory fish. Submarine pipeline has now been installed from which liquor is discharged at depth of 340′ and pollution has been reduced to minimum. Experiments are being made to evaluate sulfite liquor as soil conditioner and for irrigation of crops.—*WPA*

(*Continued on page 70*)

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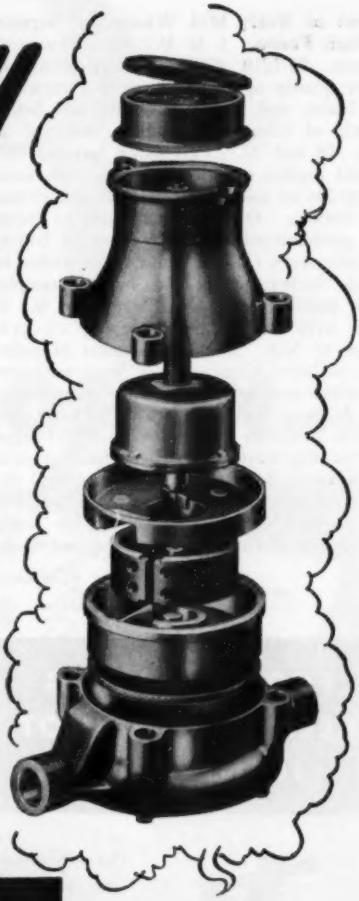

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(Continued from page 68)

Effect of Kraft Mill Wastes on Stream Bottom Fauna. J. N. WILSON. Sew. Ind. Wastes, **25**:1210 ('53). Investigations of water quality of lower 12 mi of Clearwater R., Idaho, and Snake R. above and below mouth of Clearwater, were conducted in Aug. '50 and '51. This paper includes biological studies on bottom fauna, with some discussion of correlated physical and chemical features. Owing to swiftness of rivers and predominantly rocky bottom, all bottom samples were collected in shallow riffles by using Surber square-foot bottom sampler with trailing net. On Clearwater R., 49 sq ft were sampled; on Snake, 19 sq ft. Prior to Nov. '50 major sources of pollution on lower Clearwater R. were untreated municipal and industrial wastes from Lewiston, Idaho. Beginning late in '50 kraft pulp mill at Lewiston started operation and began discharging wastes into Clearwater at point immediately downstream from municipal water treatment plant. Investigation of Aug. '51 showed deterioration in visible water quality and in character of stream bed downstream from discharge point. Under conditions of flow at that time, most of effect of waste was limited to sections of varying width on south side of river. In general, water in Clearwater was less turbid and softer than in Snake R. Although DO and BOD were little affected by discharge of pulp mill wastes to stream, presence of toxic substances (sulfides, mercaptans, and resin acid soaps) known to be components of kraft pulp mill wastes, and carbohydrate fractions, which stimulate growth of sewage fungi, rendered conditions in affected areas of Clearwater R. untenable for most bottom fauna normally expected to be found in such river. Snake R. and those areas of Clearwater not physically within zone of influence of wastes were essentially comparable biologically in 2 successive years under investigation.—*PHEA*

A Standardized Method for Determining Toxicity of Pure Compounds to Fish. L. FREEMAN. Sew. Ind. Wastes, **25**:845 ('53). Method has been developed for determining

(Continued on page 72)

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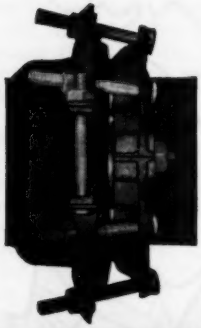

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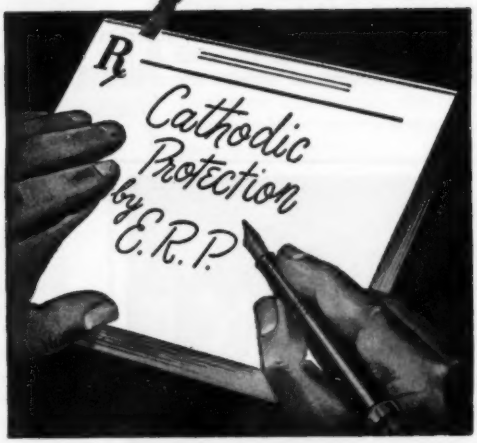

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(*Continued from page 70*)

toxicity tolerance limits of fish to pure compounds, method having advantage of being readily reproducible in any laboratory. Reproducibility is made possible by use of standardized water, designated as "standard reference water," for dilution and acclimatization purposes. This water is readily duplicated, as it is prepared from distilled water and given amounts of inorganic salts. Method described has been used successfully for bioassay work, employing both invertebrate and vertebrate animals, and is currently being employed in laboratory at Louisiana State Univ.—*PHEA*

WELLS AND GROUND WATER

Ground Water Behavior in the Hershey Valley, Pennsylvania. R. M. Foose. Bul. Geol. Soc. Amer., **64**:623 ('53). Geol. studies have been made on about 100 wells and springs in Annville limestone unit of Beekmantown limestone that underlies Hershey Valley, to ascertain effect of new pumping operations on ground water level. Water elevation, temp., pH, dissolved solids, together with yield of springs and details of ground water movement, were investigated. Area of high pH follows Annville limestone, and linear pattern of pH values tends to follow established directions of easiest ground water movement. Differences in pH values indicate boundary between major rock types. High concns. of dissolved solids indicate "ponding" of water, with little or no movement, while uniformly low concns. generally define path of movement. Differences in concn. values reflect fairly well boundary between major rock types. Contour maps, showing pH and dissolved-solids concns., are given. Results of ion concn. studies are inconclusive.—*CA*

Effect of Vegetation on Ground Water Yield. B. F. van Nievelt. Water (Neth.), **36**:195 ('52). Series of lysimeters installed in dune area in '41 have been under constant observation to obtain information regarding useful yield of ground water under different plant growth conditions. Lysimeters were: [1] bare, [2] covered with dune vegetation, [3] covered with deciduous growth, and [4] covered with coniferous growth. Trees were planted as seedlings in '41 and had reached avg height of 125 cm for deciduous and 265 cm for coniferous growth in '51. During first 4 yr useful water yield decreased in order of 1, 4, 3, 2, whereas, during next 5 yr, decreasing yield was in order of 1, 3, 2, 4. There were considerable variations in monthly precipitation and useful yield. In dry period of early '48 to fall of '49, yield of ground water was extraordinarily low, resulting in material decrease in ground water levels. Relative cumulative precipitation (cu m) and useful yields (cu m) for '43–'51 inclusive were about as follows (taken from curves): precipitation, 4,200; Lysimeter 1, 3,400; Lysimeter 2, 2,400; Lysimeter 3, 2,600; and Lysimeter 4, 2,350. It is evident that coniferous growth does not aid water yield. It is expected that difference between lysimeters covered with dune vegtation and coniferous growth will increase with further development of trees. Explanation given for more favorable conditions of deciduous growth over coniferous trees is that former lose their leaves and more water reaches soil. Calculations made regarding relation between rainfall and evaporation indicate that evaporation is

(*Continued on page 74*)

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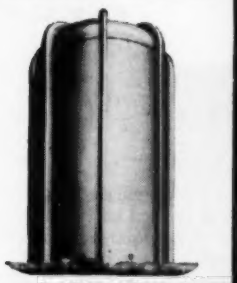

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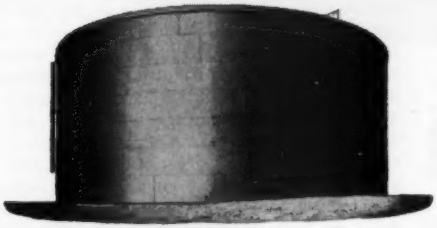

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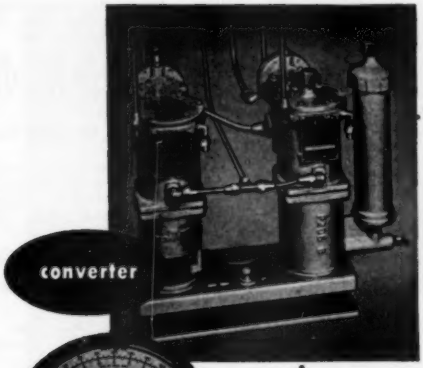
(Continued from page 72)

greater during wet than during dry years. —*W. Rudolfs*

Notes on the Theory and Formulae Associated With Pumping Tests for the Determination of Formation Constants. J. INESON. J. Inst. Wtr. Engrs. (Br.), 6:443 (Oct. '52). In '48 Geological Survey commenced series of controlled pumping tests during which opportunity was taken to examine usefulness of formulas relating to discharge of wells. Purpose of this paper is to outline methods of applying them and conditions which limit their use. Darcy's law requires that flow be proportional to first power of hydraulic gradient and, therefore, laminar. Determination of permeability is essential to estimation of availability of ground water in aquifer. Dupuit formula for water table conditions can be expressed as $P = \frac{17.591Q}{h_e^2 - h_w^2} \times \log_{10} \frac{r_e}{r_w}$. [See below for explanation of symbols.] Between r_w and r_e, cone of depression stands higher than curve defined by equation, difference being greatest at well face where seepage surface exists. Thiem's formula is expressed as $P = \frac{8.795Q}{m(s_1 - s_2)} \times \log_{10}\left(\frac{r_2}{r_1}\right)$. Strictly speaking, this formula applies only to artesian conditions where m remains unchanged during pumping. As result of extensive pumping tests, Wenzel introduced limiting and gradient formulas in attempt to eliminate some of anomalies arising in use of Thiem formula when natural conditions depart from assumed ideal. Jacob showed modification introduces unnecessary computations. He indicated further that same results can be obtained by using modification of Theis nonequilibrium formula. By adapting modification for case when t and Q are constant, it can be shown that $T = -8.795Q\left(\frac{\partial \log_{10} r}{\partial s}\right)$ where $\frac{\partial \log_{10} r}{\partial s}$ is slope of linear plot of s against $\log_{10} r$. Both Theim's formula and Jacob's modification can be further adapted for additional discharging wells and T can be obtained by either calculation or graphical methods. Above formulas, referred to as equilibrium formulas, depend on existence of steady flow around discharging well. Frequently during pumping test, equilibrium would be attained only in neighborhood of well, and elsewhere nonsteady conditions of flow would exist. Theis expression for nonequilibrium condition is: $s = \frac{1.91Q}{T}\left(-0.5772 - \log_e u + u - \frac{u^2}{2 \times 2!} + \frac{u^3}{3 \times 3!} - \ldots\right)$. Solution of this equation is complicated and it is best to use graphical method suggested by Theis. Development of nonequilibrium formulas assumes following theoretical conditions, some of which are applicable to equilibrium formulas: [1] homogeneous aquifer of infinite lateral extent; [2] pumped well of infinitesimal diameter and penetrating full thickness of aquifer; [3] T and S to remain constant within aquifer at any time; [4] decline in pressure head to release water from storage immediately; [5] flow of water to be laminar and radial; and [6] overlying and underlying beds to be impermeable. When hydraulic boundary conditions, such as faulting, structural deformations, and recharge phenomena, become important, analysis based on method of images is frequently adopted. Formulas must be applied carefully, as their practical success will depend on extent to which natural conditions conform to theoretical assumptions. Symbols used are: h_e, thickness of saturated part of aquifer at distance r_e from discharging well (ft); h_w, thickness of saturated part of aquifer at well face (ft); m, thickness of saturated part of aquifer (ft); P, coeff. of permeability (gpd/sq ft); Q, rate of discharge of well (gph); r, r_1, r_2, distance of observation wells from discharging well (ft); r_e, radius of cone of depression (ft); r_w, radius of discharging well (ft); s, s_1, s_2, drawdown in observation wells at distances r, r_1, r_2, from discharging well (ft); S, coeff. of storage (cu ft); t, time since discharge commenced or ceased (days); T, coeff. of transmissibility (gpd/ft).—*H. E. Babbitt*

Recharging Wells Expected to Stem Sea Water Intrusion. F. B. LAVERTY. Civ. Eng., 22:25 (May '52). This article discusses problem of sea water pollution of fresh-water wells in West Coastal Basin of Los Angeles County. 5 solutions are presented, with combination of 2 being chosen for pilot program which started in '52: direct recharging of polluted wells and creation of fresh-water barrier. Pilot program is limited only by present capacity of water distribution lines. State appropriations are providing necessary funds for investigation of this serious menace to water supply of West Coast.—*PHEA*



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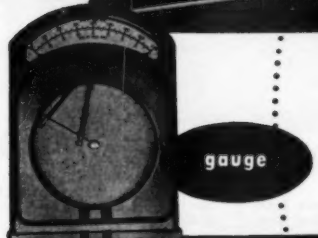

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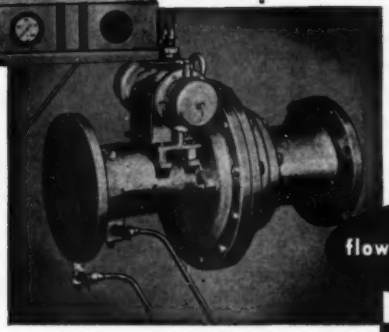

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Bonney, Charles H., Prof. of San. Eng., Box 1609, Vanderbilt Univ., Nashville 4, Tenn. (July '54) *MRP*

Boyce, Robert Q., Civ. Engr., Ripple & Howe, 833—23rd St., Denver, Colo. (July '54) *RPD*

Brieant, Charles L., Jr., Atty., Bleakley, Platt, Gilchrist & Walker, 8 Church St., White Plains, N.Y. (July '54) *MR*

Brown, Thomas S., Supt., King County Water Dist. No. 43, 2849 S. 150th St., Seattle 88, Wash. (July '54)

Browning, Roscoe O., Operator, National Gypsum, Parsons, Kan. (July '54) *P*

Bush, Bernard S., Regional Engr., State Dept. of Health, Kirby Health Center, Wilkes-Barre, Pa. (July '54) *MRPD*

Carmichael, David C., Sr. Power Design Engr., E. I. du Pont de Nemours & Co., Wilmington, Del. (July '54) *RP*

Corbitt, Edgar T., Operator, Filter Plant, North Augusta, S.C. (July '54) *MP*

Davies, John, Design Engr., Engineering Service Corp., 1127 W. Washington Blvd., Los Angeles, Calif. (July '54)

Detwiler, John S., Proprietor, Key Chemical Co., 56—14th St., San Francisco 3, Calif. (July '54)

Fisher, Ralph W., Supt., Maint. & Water Works, Box 787, Marfa, Tex. (July '54) *MRPD*

Galbraith, Martin; *see* Sutherland Paper Co.

Geissinger, Richard M., Dist. Engr., Electro Rust-Proofing Corp., 6140 W. Appleton Ave., Milwaukee 10, Wis. (July '54) *MP*

Gemmell, John A., Mgr., Independence Water Co., Box 105, Independence, Calif. (July '54) *M*

Gilbert, George W., Water Distr. Supervisor, Dept. of Water, Philadelphia, Pa. (July '54) *MD*

Good, Frank J., Jr., Distr. Mgr., Sales & Service, Sparling Meter Co., 3530 Forbes St., Pittsburgh 13, Pa. (July '54) *M*

Gothie, Joseph F., Water Distr. Supervisor, Dept. of Water, Philadelphia, Pa. (July '54)

Gwin, Louis F., Engr., 201 Aldrich Ave., Altoona, Pa. (July '54)

Hack, George D., Research Analyst, Div. of Resources & Development, Jefferson Bldg., Jefferson City, Mo. (July '54) *R*

Hager, W. R., San. Engr., State Dept. of Health, Bureau of Eng., Regional Office, 916 Diamond, Meadville, Pa. (July '54) *MRP*

Hamilton, Robert F., Partner, Hamilton & Voeller, Bistline Bldg., 417 E. Center St., Pocatello, Idaho (July '54) *M*

Harris, Robert E., Jr., Instrumentation Engr., Minneapolis-Honeywell Regulator Co., Dallas, Tex. (July '54) *P*

Hayter, Robert B., Director, Public Works, City Hall, Paris, Tex. (July '54) *MPD*

Hewitt, Jack, Exec. Vice-Pres., Lebanon Chemical Co., Box 532, Lebanon, Pa. (July '54) *P*

International Business Machines Corp., Hugh Knickerbocker, Mgr., Plant Services Dept., Plant No. 2, South Rd., Poughkeepsie, N.Y. (Corp. M. July '54) *P*

Joseph, S. J.; *see* Northwest Utilities Co.

Keller, W. F., Water Works, 194 Main St., Emmaus, Pa. (July '54) *M*

Knickerbocker, Hugh; *see* International Business Machines Corp.

Lambert, Gordon H., Vice-Pres. & Gen. Mgr., Shreveport Branch, Lambert Associated Co.'s, Inc., 727 Azalea Dr., Shreveport, La. (July '54) *P*

Langston, C. E.; *see* Mission (Tex.)

Merritt, Ferd M., Supt., Water Dept., Chadron, Neb. (July '54) *MRP*

Mission, City of, C. E. Langston, Water Supt., City Hall, Mission, Tex. (Corp. M. July '54) *M*

Mollanen, Toivo E., 8501 S. 112th St., Seattle 88, Wash. (July '54)

Morgan, John H., Supervisor, Asbestos Pipe Dept., Atlas Asbestos Co., Ltd., 224 Davenport Rd., Toronto, Ont. (July '54)

North Castle, Town of, Louis J. Stipo, Supt., Water Dept., Armonk, N.Y. (Munic. Sv. Sub. July '54) *MRP*

Northwest Utilities Co., S. J. Joseph, Gen. Mgr., 9160 N. Clarkson, Denver 16, Colo. (Corp. M. July '54) *MRPD*

Paulin, James H., Jr., Eng. Asst., Munic. Water Dept., 3525 Pershing Ave., San Bernardino, Calif. (July '54) *MRPD*

Prendergast, John J., Civ. Eng. Asst., Dept. of Water & Power, 207 S. Broadway, Los Angeles, Calif. (July '54) *MD*

Reilly, Robert C., Project Supt., Bates & Dungey, RR 1, Box 1059A, Pompano Beach, Fla. (July '54) *RP*

Sandt, Hartley, Sales Repr., Johns-Manville Sales Corp., 270 Madison Ave., New York 16, N.Y. (July '54) *D*

Scott, Frances P., Mrs., Asst. Supt., Water Works Board, Box 25, Leeds, Ala. (July '54) *M*

Sellers, John B., Supt., Water Treatment Plant, Box 1082, Vero Beach, Fla. (July '54) *M*

Sholin, George E., Gen. Mgr., Willow County Water Dist., 1215B S. Highway, Ukiah, Calif. (July '54) *MRPD*

Stipo, Louis J.; *see* North Castle (N.Y.)

Sullivan, Donald Lewis, Chem. Engr., Library Business Service, Eli Lilly & Co., 740 S. Alabama St., Indianapolis 6, Ind. (July '54) *RP*

Sutherland Paper Co., Martin Galbraith, Tech. Director, 243 E. Paterson St., Kalamazoo, Mich. (Corp. M. July '54) *P*

Tomasini, Louis F., Supt. of Water, 513 Elm St., Norway, Mich. (July '54)

Tyman, Albert, Water Distr. Supervisor, Dept. of Water, 29th & Cambria St., Philadelphia, Pa. (July '54)

Watson, Arthur E., Dist. Engr., State Dept. of Health, Oklahoma City, Okla. (July '54) *MRPD*

Watson, George E., Supt., Water Works Dept., Water Works Board, Punta Gorda, Fla. (July '54) *MRPD*

Whipple, William C., Sales Repr., Badger Meter Mfg. Co., 2940 Leonis Blvd., Los Angeles 58, Calif. (July '54) *D*

Wyke, Ralph R., Pres., Diggerman, Inc., 1782 Chestnut Ave., Wyandotte, Mich. (July '54)

Yoder, Lynn D., Supt., Water Treatment Plant, US Sugar Corp., Clewiston, Fla. (July '54) *MRP*

Zeller, P. J. Alwin, Asst. Research Engr., Texas A & M College, Box 5664, College Station, Tex. (July '54) *P*

Zowarka, Joe A., Water & Sewer Supt., Box 135, Runge, Tex. (July '54) *D*

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(See story on p. 33 P&R)

Laying a section of 42-in. pipe on Hearne Avenue, just east of the Cincinnati Zoo.

Cincinnati Meets Increased Water Demands with New 42-in. Tar-Enameled Steel Main

The Cincinnati Water Works recently came up with a single answer to the double problem of how to supply the fast-increasing water demands of (1) the mid-city commercial and industrial Central Service section, and (2) the growing Western Hills residential area (see map).

Their solution called for a 36,000-ft-plus steel main, 42 in. ID, to connect the Main and Tennyson pumping stations with the Winton Road Reservoir. The added gallonage would be used to serve the Eastern and Western Hills, thereby releasing a huge quantity of water for Central Service. Steel pipe was considered a "must" to handle the working pressures involved, sometimes as high as 200 psi.

Now nearing completion, the line starts at the corner of Union St. and Burnet Ave., in front of the Cincinnati General Hospital, and extends through Avondale, Clifton, and Winton Place to the Winton Road Reservoir in the heights north of the city.

All of the pipe used on this job, together with a variety of fittings, was supplied by Bethlehem, making the seventh time since 1938 that Cincinnati has chosen Bethlehem Pipe.

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The Reading Meter

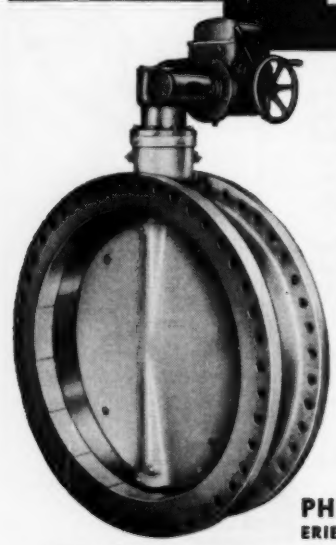
(Continued from page 54 P&R)

Collège Radiesthésique Français aren't demanding their money back. As for our homegrown dowsers, we have an idea that very few will aspire to the role of radiesthetists. Certainly there can't be many who would involve themselves in the considerable inconvenience of determining their own polarity and its effects under various conditions, discovering and learning how to counteract a thousand and one interferences from color to wire, from radioactivity to geological faults, or versing themselves in even the vocabulary of advanced electrodynamics.

Not only will our practical dowsers probably find Mme. Maury's brew a little too rich for their witching, but the theoretical enthusiasts are quite likely to be disappointed, finding her basic ideas rather too physical for their taste. Details, too, such as her recommendation against the use of "natural wood rods," her contention that "no detection is reliable unless a sample [and a sample of the exact composition desired] is used," her insistence on the need for mechanical amplification apparatus, and her point that a knowledge of the geologic conditions of an area is prerequisite to a reliable estimate of yield, will not sit too well with the trade.

For our part, neither the 21 lessons and accompanying exercises that make up Part I of the book, nor the medical radiesthesia, characterized as "revolutionary, ranking in importance superior to the great medical discoveries of the last century," that constitute Part II, were entirely understandable. Beyond learning to appreciate the ocular impact of Mme.

(Continued on page 80 P&R)



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The Reading Meter

(Continued from page 78 P&R)

Maury's pet "gauss," or discovering why lightning usually strikes even more than twice in the same place, or finding that "the good water diviner . . . is generally of an arthritic constitution," we felt our store of usable knowledge quite unaugmented. We might have been happier if Madame had extended to water diviners her good counsel to mineral and oil detectors: "Radiesthetic indications should always be verified by geophysical prospecting instruments." Then again—considering all the garbage about the hypersensitivity and irreproducibility of radiesthetic razzmatazz—perhaps not!

One thing we can suggest, though. To the dowser who will overlook the occasional breaches of the diviner code, Mme. Maury has provided a source book of alibis couched in terminology superscientific enough to make them almost universally acceptable.

Proceedings of the 1953 Conference on Instrumentation in Water, Sewage, and Industrial Waste Treatment. *Manhattan College, New York (1954) 46 pp.; paperbound; $2.00 from Instruments Pub. Co., 845 Ridge Ave., Pittsburgh 12, Pa.*

A collection of 21 papers on various aspects of instrumentation presented at the Manhattan College annual conference on this subject. Contributors included members of the faculty of Manhattan College and New York Univ., some local water works and sewage people, and representatives of various consulting and commercial firms.

Proceedings of the Sixteenth Annual Short Course for Water and Sewerage Plant Superintendents and Operators, 1953. *Bul. 41, Engineering Experiment Station, Louisiana State University and Agricultural & Mechanical College, Baton Rouge 3, La. (1954) 128 pp.; paperbound; $1*

Among the lectures included are discussions of well rehabilitation, centrifugal pump maintenance and conversion, dry chemical feeders, main disinfection, and hydraulics.

Effects of Bombing on Industry. *Catalog of Technical Reports (CTR) 245. Office of Technical Services, Business and Defense Services Administration, US Dept. of Commerce, Washington 25, D.C. (1954) 4 pp.; paperbound; 10¢*

A catalog of reports available for purchase from the Dept. of Commerce or Library of Congress on various aspects of the impact of bombing upon industries and national economy.

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(Continued from page 48 P&R)

Hold Your Water! has become rather a large order of late with one area after another casting covetous eyes on other people's rivers. Time was when a river in the backyard could pretty much be trusted to stick around, but today's pumps and pipelines have changed all that.

It was probably Los Angeles and New York that started the riverine rhubarbs with their tapping of the Colorado and the Delaware. In each case, it took a Supreme Court decision to establish just how much of the river was whose. What it will take for the newer, bigger ideas is difficult even to imagine. California, for instance, was busy talking of drawing a large supply from the mouth of the Pacific-Northwest's Columbia River and pumping it the 1,100 miles to semi-arid Southern California until distracted temporarily by the substitution of two more modest ideas that will involve less interstate hostility—a 600-mile pipeline to the Feather River in the northern part of the state or a somewhat longer one to the Klamath River or the Trinity River, even further north. Meanwhile, Texas, too, has been having big ideas —Big Muddy, in fact—and has introduced a bill in Congress calling for an $8,500,000 study of how the Missouri can be diverted to serve the high and dry plains of the Panhandle. And New York, of course, has just won its second scoop of Delaware River water via the Supreme Court after an interstate compact failed to get through the Pennsylvania Legislature.

Not all the rivalry has been interstate either. Such local struggles as the Fallbrook affair, in which a California utility district did battle with the Marine Corps for the waters of the Santa Margarita River, and other water rights litigation throughout the Southwest have been constant and choleric. And the current drought has brought the problem down to the level of the individual farmer in New Jersey and his right, in common law, to appropriate only the surplus water from the stream passing his farm. Extranationally, meanwhile, the contention has been international. Pakistan and India, for example, have long been at odds because of their struggle for the waters of the Indus. And in the headlines now are Egypt's claims that Israel is "grabbing" the waters of the Jordan, thereby depriving Arab countries and Arab refugees.

Water is still where you find it, but finders, it seems, aren't necessarily keepers.

Alfred C. Ingersoll, assistant professor of civil engineering at California Inst. of Technology, has been granted a leave of absence to serve at the Bengal, India, Engineering College as a Point Four specialist in engineering fluid mechanics. He will aid in establishing a fluid mechanics laboratory on the college grounds at Sibpur. The appointment was made by the Univ. of Wisconsin, which has established sisterhood relationships with the Bengal college and recruits engineering professors to serve there. Advanced training in the United States is also arranged for visiting Indian professors.

Guy Scrivner has been appointed head of the newly organized Municipal Sales Dept. of Le Roi Co., makers of standby generator sets and centrifugal pumps. The firm is a subsidiary of Westinghouse Air Brake Co.

Victor L. Streeter has been appointed professor of hydraulic engineering at the Univ. of Michigan.

(Continued on page 84 P&R)

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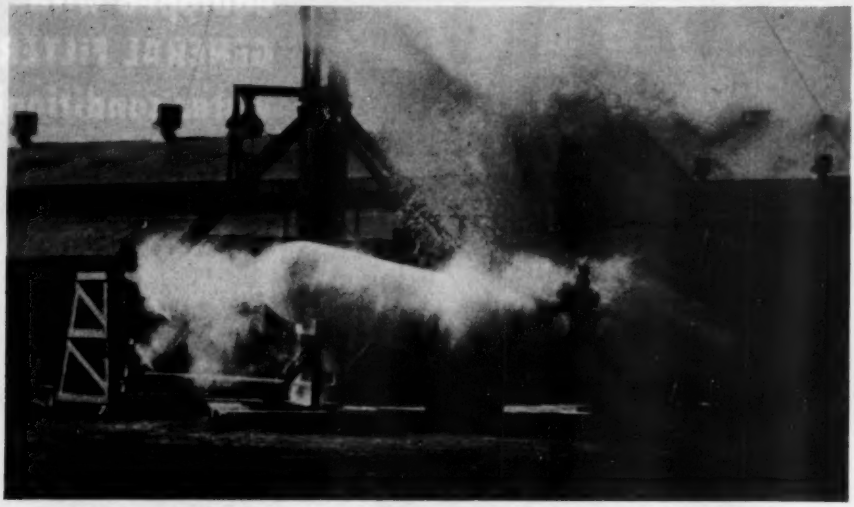
(Continued from page 82 P&R)



Spectacular bursting test shows how new Carilloy steel of US Steel Corp., filled with brine at −45°F, lets go at 2,850 psi. Test was made at Chicago Bridge & Iron Co. plant in Birmingham, Ala.

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Section Meetings

Pennsylvania Section: The Sixth Annual meeting of the Pennsylvania Section was held June 23–25, 1954, at the Americus Hotel in Allentown, with 234 members and guests attending.

Chairman L. D. Matter opened the technical sessions on Wednesday afternoon. A movie on "The Construction of the North Wayne Tanks" for the Philadelphia Suburban Water Co. was shown, and greetings extended from Mayor Brighton C. Diefenderfer. The technical session for Wednesday afternoon was headed by a discussion on repair of concrete water works structures, with Charles W. Stickler Jr., president, Manu-Mine Research & Development Co., of Reading, discussing "Effective Treatment of Water Loss Through and Around Concrete Retaining Walls and Dams" and Christopher J. McNally, general manager and chief engineer of the Cement Gun Co., Inc., Allentown, discussing "Gunite in the Water Works Field." Hugh L. Hamilton, A. V. Smith Eng. Co., Ardmore, reported on "Cathodic Protection on Water Lines," and Gerald E. Arnold, general superintendent, Philadelphia Water Dept., presented a paper on "Butterfly Valves for Water Works Operation." At a business session, AWWA Secretary Jordan brought greetings from the parent organization. Committee reports were given, and the following new officers were elected: chairman, R. B. Adams; vice-chairman, F. S. Friel; trustee, B. F. Johnson; secretary-treasurer, L. S. Morgan.

While the men attended the technical sessions in the afternoon, the ladies were entertained at a bridge party in the Green Room of the Americus Hotel. Dinner that night was in the form of a Smorgasbord, and this affair was well attended. For those interested, tickets were available for a little theater party, "Musical Circus," that evening. For meeting old friends and making new ones, the Water and Sewage Works Manufacturers Assn. sponsored a convention get-together Wednesday night.

The technical sessions Thursday morning were presided over by Vice-Chairman J. L. Matthews. A motion picture "Adam to Atom," prepared by the American Society of Civil Engineers, was shown. A panel discussion was then presented on "Fundamentals of Water Works Practice." L. D. Matter, assistant chief engineer of the Bureau of San. Eng., State Dept. of Health, Harrisburg, dealt with "Supply"; Martin E. Flentje, research engineer, American Water Works Service Co., Philadelphia, discussed "Purification"; Victor Appleyard, chief of operations of the Philadelphia Water Dept. discussed "Pumping"; and George F. Eynon, manager of the South Pittsburgh Water Co., Pittsburgh, ended the discussion with a paper on "Distribution."

Luncheon for the men was at the Allentown Filter Plant, where the honored guests were those receiving Life Membership Awards: M. J. Barrick, J. G. Griffiths, C. W. Kunkle Sr., F. W. Lawrence, M. G. Mansfield, E. R. Weidlein, and C. C. Wilbur. The technical sessions, presided over by Trustee R. B. Adams, continued that afternoon at the filtration plant and included a paper by M. A. Slone, Morris Knowles, Inc., Pittsburgh, on "Water Works Improvements at Allentown," after which a tour of inspection was made of the plant. A civil

(*Continued on page 88 P&R*)

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SAN FRANCISCO —
LOS ANGELES

Section Meetings

(Continued from page 86 P&R)

defense demonstration included the installation and operation of emergency filtration, pumping and chlorination equipment, and the assembly of transmission and distribution system piping.

In the meantime, the ladies were taken on a tour of Allentown Thursday morning. This was followed by luncheon and a show of the latest fashions at Hess Brothers Dept. Store.

The manufacturers association sponsored a social hour immediately before the annual banquet. At the banquet, the guest speaker was AWWA Secretary Jordan. The George Warren Fuller Award nomination was accorded Harry James Krum by L. S. Morgan, chairman of the Fuller Award Committee. Entertainment for the evening was Pennsylvania Dutch style, provided by the Reinsmith-Kulowitsch Orchestra, after which there was dancing.

Friday morning sessions were presided over by Chairman Matter, beginning with a paper on "Activated Silica as a Coagulant Aid" by A. E. Griffin, director, Technical Service Div., Wallace & Tiernan Inc., Newark, N.J., and discussed by A. B. Middleton, Chemical Dept., Philadelphia Quartz Co., Philadelphia. A discussion on "Two-Way Radio Communications in the Water Works Field" was presented by George H. Dann, vice-president and general manager, Philadelphia Suburban Water Co., Bryn Mawr; D. K. Phillips, general sales manager, Central Area, Bell Telephone Co., Harrisburg, and Frank M. Girard, district sales manager, General Electric Co., Philadelphia.

The final business session was held Friday morning and the conference was adjourned at noon.

L. S. MORGAN
Secretary-Treasurer

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1. It feeds uniformly, without trouble, in solid or liquid form.
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Service Lines

Repair clamps and service fittings of M. B. Skinner Co., South Bend, Ind., are described and fully illustrated in a 48-page catalog available on request. Application information, specifications, and installation instructions are included. Drilling devices and coupling saddles for tapping services into mains under pressure are also shown.

"Sources of Water," a folder designed to acquaint industrial water users with the necessity for adequate investigations into the water supply situation, is being distributed by Hall Labs., Inc., Hagan Bldg., Pittsburgh 30, Pa.

Three sound slidefilms on the subject of V-belt drives have been prepared for in-service training or educational purposes by the General Machinery Div., Allis-Chalmers Mfg. Co., Milwaukee 1, Wis., and may be obtained from local district offices. "In Every V-Belt Drive" discusses basic engineering principles; "For Better Driving" discusses installation and maintenance practices; and "Selecting a Drive" discusses proper selection.

Flexible shafting to provide manual control of valves in inaccessible or unsafe locations is described in a 16-page design manual of Stow Mfg. Co., 443 State St., Binghamton, N.Y.

"Instrumentation and Control for Water Filtration Plants," a 16-page circular on the operation of various types of meters, gages, and flow controllers, may be obtained from Builders-Providence, Inc., 345 Harris Ave., Providence 1, R.I. The booklet is also known as Bul. 100-K2.

(Continued on page 92 P&R)

THE

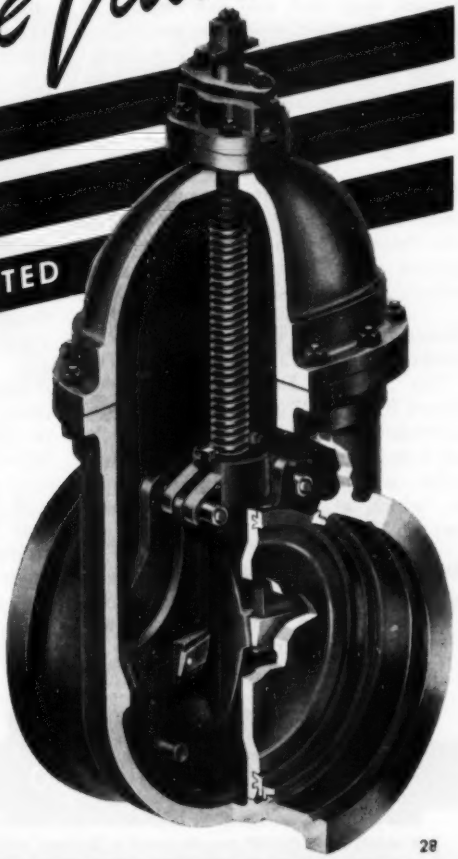
SMITH

Gate Valve

MANUAL,

ELECTRIC OR

CYLINDER OPERATED



The unique side wedging action employed in the Smith Gate Valve positively prevents premature lateral expansion of the discs and consequent binding and scoring of the seats while the valve is being operated.

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FIRE HYDRANTS · VALVES SINCE 1896

THE A.P. SMITH MFG. CO.

EAST ORANGE, NEW JERSEY

Service Lines

(Continued from page 90 P&R)

Centrifugal pumps in the De Laval GS (general service) line are described in a folder, Bul. 1001B, available from De Laval Steam Turbine Co., Trenton 2, N.J. The pumps range in size from 2½ to 4 in. and offer capacities up to 400 gpm; heads up to 230 ft. A cutaway drawing shows design features.

Diesel, dual fuel, and gas engines of the Worthington Corp., are depicted in typical installations in a 44-page bulletin, No. S-500-B13C, which is being distributed by the Advertising and Sales Promotion Dept. of the company at Harrison, N.J.

How concrete pressure pipe is designed, manufactured, laid, and utilized is the "story" of "The Story of Concrete Pressure Pipe," available from Price Brothers Co., Box 825, Dayton 1, Ohio.

Conversion of a water supply well to a water disposal well is described in Vol. 18, No. 5 of the Dowell *Acidizer,* distributed by Dowell Inc., Tulsa 1, Okla. Waterfrac—a method of employing thickened water and sand to fracture the formation—was used to open up the formation, which at first would not accept water at 700 psi.

Rotoseal rotary distributors for trickling filters are described in Bul. 23S70 of Walker Process Equipment Inc., 840 N. Russell Ave., Aurora, Ill.

How industrial water conditioning problems are met is the subject of a pamphlet entitled "What Is Hall Laboratories?" Copies may be obtained from Hall Labs., Inc., Hagan Bldg., Pittsburgh 30, Pa.

A convenient rack for steel rounds, flats, angles, sheets, bars, and other shapes is featured in a circular on the Handi-Steel Mill, available from Electro-Hercules Steel Co., 1448 E. 49th St., Cleveland 3, Ohio. The rack and its assortment of steel is intended to supply maintenance men with an assortment of the most popular sizes and shapes of steel for a variety of purposes.

The Omega Loss-in-Weight Indicator-Recorder designed for use with the Model 50A Volumetric Feeder is the subject of a circular, Bul. 50-L13, available from Omega Machine Co., 345 Harris Ave., Providence 1, R.I.

Pneumatic control for the measurement and control of liquids is the subject of Bul. 5421 of the General Filter Co., 923—2nd St., Ames, Iowa.

A Sentry piston-operated valve which may be manually or automatically controlled is described in a circular available from McRae Corp., 621 S. Spring St., Los Angeles 14, Calif. A 3-way valve on a ¼-in. line controls the actuating hydraulic piston.

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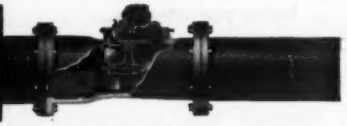

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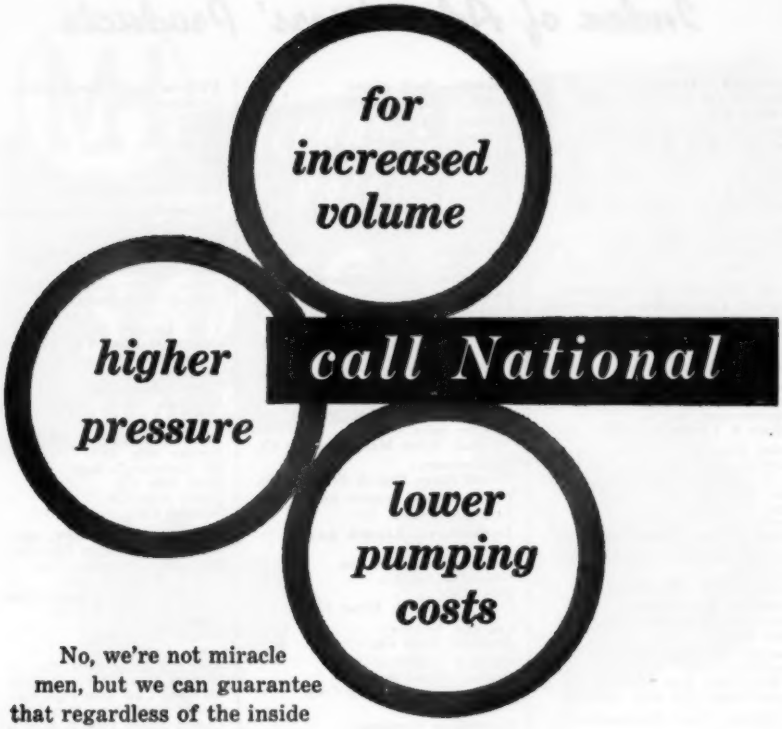

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(See Prof. Services, pp. 25–29)

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(See Prof. Services, pp. 25–29)

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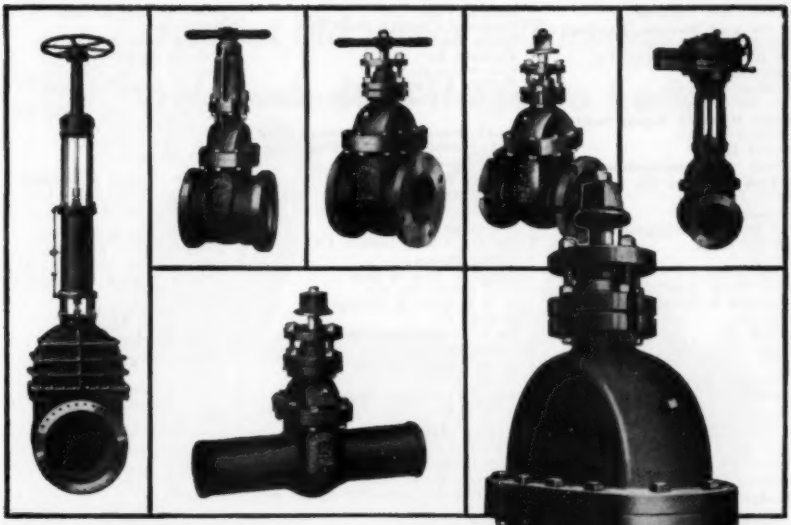

KENNEDY

A.W.W.A. GATE VALVES

JOB-FITTED

...for a wide range of water works requirements

KENNEDY Fig. 56, A.W.W.A. Standard Double-Disc Gate Valve

Every KENNEDY A.W.W.A. valve job is JOB-FITTED . . . specially designed and engineered for the job it has to do. Conforming to A.W.W.A. standards in every detail, these KENNEDY valves offer many extra-value features . . . one being the iron itself, which is 50% stronger than ordinary cast-iron . . . to keep them on the job year in and year out.

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WRITE FOR BULLETIN 106

Est. 1877

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Roberts Filter Mfg. Co.
Walker Process Equipment, Inc.

Softening Chemicals and Compounds:
Calgon, Inc.
Cochrane Corp.
General Filter Co.
Infilco Inc.
Permutit Co.
Tennessee Corp.

Standpipes, Steel:
Chicago Bridge & Iron Co.
Pittsburgh-Des Moines Steel Co.

Steel Plate Construction:
American Locomotive Co.
Bethlehem Steel Co.
Chicago Bridge & Iron Co.
Pittsburgh-Des Moines Steel Co.

Stops, Curb and Corporation:
Hays Mfg. Co.
James Jones Co.
Mueller Co.
Welsbach Corp., Kitson Valve Div.

Storage Tanks; see Tanks

Strainers, Suction:
James B. Clow & Sons
M. Greenberg's Sons
Johnson, Edward E., Inc.
R. D. Wood Co.

Surface Wash Equipment:
Cochrane Corp.
Permutit Co.

Swimming Pool Sterilization:
Everson Mfg. Corp.
Omega Machine Co. (Div., B-I-F Industries)
Proportioneers, Inc.
Wallace & Tiernan Inc.
Welsbach Corp., Ozone Processes Div.

Tanks, Steel:
American Locomotive Co.
Bethlehem Steel Co.
Chicago Bridge & Iron Co.
Pittsburgh-Des Moines Steel Co.

Tapping-Drilling Machines:
Hays Mfg. Co.
Mueller Co.
A. P. Smith Mfg. Co.

Tapping Machines, Corp.:
Hays Mfg. Co.
Mueller Co.
Welsbach Corp., Kitson Valve Div.

Taste and Odor Removal:
Cochrane Corp.
General Filter Co.
Industrial Chemical Sales Div.
Infilco Inc.
Permutit Co.
Proportioneers, Inc.
Wallace & Tiernan Inc.
Welsbach Corp., Ozone Processes Div.

Turbidimetric Apparatus (For Turbidity and Sulfate Determinations):
Wallace & Tiernan Inc.

Turbines, Steam:
DeLaval Steam Turbine Co.

Turbines, Water:
DeLaval Steam Turbine Co.

Valve Boxes:
James B. Clow & Sons
Ford Meter Box Co.
M & H Valve & Fittings Co.
Mueller Co.
Pacific States Cast Iron Pipe Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Valve-Inserting Machines:
A. P. Smith Mfg. Co.

Valves, Altitude:
Ross Valve Mfg. Co., Inc.

Valves, Butterfly, Check, Flap, Foot, Hose, Mud and Plug:
Backflow Engineering & Equipment Co.
Chapman Valve Mfg. Co.
James B. Clow & Sons
Crane Co.
DeZurik Shower Co.
M. Greenberg's Sons
M & H Valve & Fittings Co.
Mueller Co.
Rensselaer Valve Co.
R. D. Wood Co.

Valves, Detector Check:
Hersey Mfg. Co.

Valves, Electrically Operated:
Belco Industrial Equipment Div.
Chapman Valve Mfg. Co.
James B. Clow & Sons
Crane Co.
Darling Valve & Mfg. Co.
Kennedy Valve Mfg. Co.
M & H Valve & Fittings Co.
Mueller Co.
Philadelphia Gear Works, Inc.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.

Valves, Float:
James B. Clow & Sons
Ross Valve Mfg. Co., Inc.

Valves, Gate:
Chapman Valve Mfg. Co.
James B. Clow & Sons
Crane Co.
Darling Valve & Mfg. Co.
Dresser Mfg. Div.
James Jones Co.
Kennedy Valve Mfg. Co.
Ludlow Valve Mfg. Co., Inc.
M & H Valve & Fittings Co.
Mueller Co.
Pacific States Cast Iron Pipe Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Valves, Hydraulically Operated:
Chapman Valve Mfg. Co.
James B. Clow & Sons
Crane Co.
Darling Valve & Mfg. Co.
DeZurik Shower Co.
Kennedy Valve Mfg. Co.
M & H Valve & Fittings Co.
Mueller Co.
Philadelphia Gear Works, Inc.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Valves, Large Diameter:
Chapman Valve Mfg. Co.
James B. Clow & Sons
Crane Co.
Darling Valve & Mfg. Co.
Kennedy Valve Mfg. Co.
Ludlow Valve Mfg. Co., Inc.
M & H Valve & Fittings Co.
Mueller Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Valves, Regulating:
Crane Co.
DeZurik Shower Co.
Foster Eng. Co.
Mueller Co.
Ross Valve Mfg. Co.

Valves, Swing Check:
Chapman Valve Mfg. Co.
James B. Clow & Sons
Crane Co.
Darling Valve & Mfg. Co.
M. Greenberg's Sons
M & H Valve & Fittings Co.
Mueller Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Waterproofing
Gulf States Asphalt Co.
Inertol Co., Inc.

Water Softening Plants; see Softeners

Water Supply Contractors:
Layne & Bowler, Inc.

Water Testing Apparatus:
Wallace & Tiernan Inc.

Water Treatment Plants:
Allis-Chalmers Mfg. Co.
American Well Works
Belco Industrial Equipment Div.
Chain Belt Co.
Chicago Bridge & Iron Co.
Cochrane Corp.
Dorr Co.
General Filter Co.
Graver Water Conditioning Co.
Hungerford & Terry, Inc.
Infilco Inc.
Permutit Co.
Pittsburgh-Des Moines Steel Co.
Roberts Filter Mfg. Co.
Walker Process Equipment, Inc.
Wallace & Tiernan Inc.
Welsbach Corp., Ozone Processes Div.

Well Drilling Contractors:
Layne & Bowler, Inc.

Well Screens
Johnson, Edward E., Inc.

Wrenches, Ratchet:
Dresser Mfg. Div.

Zeolite; see Ion Exchange Materials

A complete Buyers' Guide to all water works products and services offered by AWWA Associate Members appears in the 1953 AWWA Directory.

Sure, that old pump still works,

but how much does it cost to keep?

That rugged old pump of yours may not be the bargain that it seems. Let's do some arithmetic. If the efficiency of the old pump is 75% vs. the 85% efficiency of the new pump, you are paying more to keep it than you would to replace it. That's because a new unit of equivalent output uses less power. Thus it soon saves its own cost—then begins to pay dividends.

Let's take a specific example—a water works pump

Old pump efficiency 84% ..... 625 BHP
New pump efficiency 89% .... 590 BHP
35 BHP Saving

On the basis of 1¢ per KWH, the 35 BHP saving for a 5000-hour year (approximately 14 hours per day) amounts to $1300. This saving, capitalized in 15 years at 5%, adds up to $28,000. Yet the price of the new pump that saves $28,000 is only $4054.

What would the pump replacement profit be in your particular case? Your De Laval representative can tell you exactly—in dollars and cents—as soon as he has the basic facts on your present installation. Call him in today or write to De Laval for Pump Fax Bulletin which includes a valuable "power-savings" chart.

DE LAVAL *Pumps*

DE LAVAL STEAM TURBINE COMPANY
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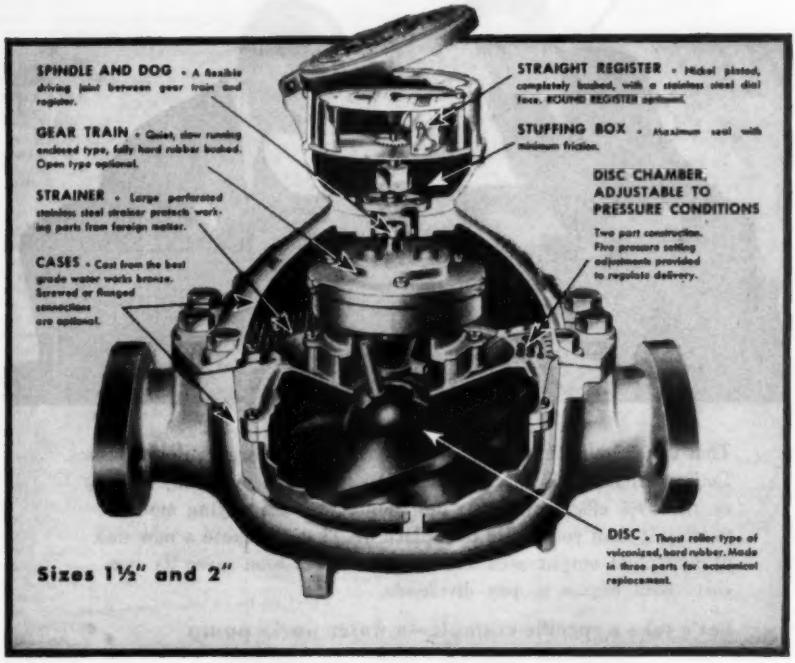
INSIDE INFORMATION
about Rockwell Type 6 Disc Meters


SPINDLE AND DOG • A flexible driving joint between gear train and register.
GEAR TRAIN • Quiet, slow running enclosed type, fully hard rubber bushed. Open type optional.
STRAINER • Large perforated stainless steel strainer protects working parts from foreign matter.
CASES • Cast from the best grade water works bronze. Screwed or flanged connections are optional.
STRAIGHT REGISTER • Nickel plated, completely bushed, with a stainless steel dial face. ROUND REGISTER optional.
STUFFING BOX • Maximum seal with minimum friction.
DISC CHAMBER, ADJUSTABLE TO PRESSURE CONDITIONS
Two part construction. Five pressure setting adjustments provided to regulate delivery.
DISC • Thrust roller type of vulcanized, hard rubber. Made in three parts for economical replacement.
Sizes 1½" and 2"

These Quality Features Mean —

GREATER ACCURACY, LONGER METER LIFE

For measurement accuracy that lasts on all your 1½" and 2" services, you can make no better choice than the Rockwell Type 6 meter. In it, you'll get every wanted feature and many extras including a measuring chamber that can be adjusted to five different positions to regulate delivery. This prolongs meter life by governing maximum allowable rate of flow in accordance with the line pressure, and prevents excessive wear due to over-speeding.

To get all the revenue from profitable commercial and small industrial services, invest now in Rockwell Type 6 meters. They will repay their cost many times through a superior degree of maintained accuracy and lowered repair costs.

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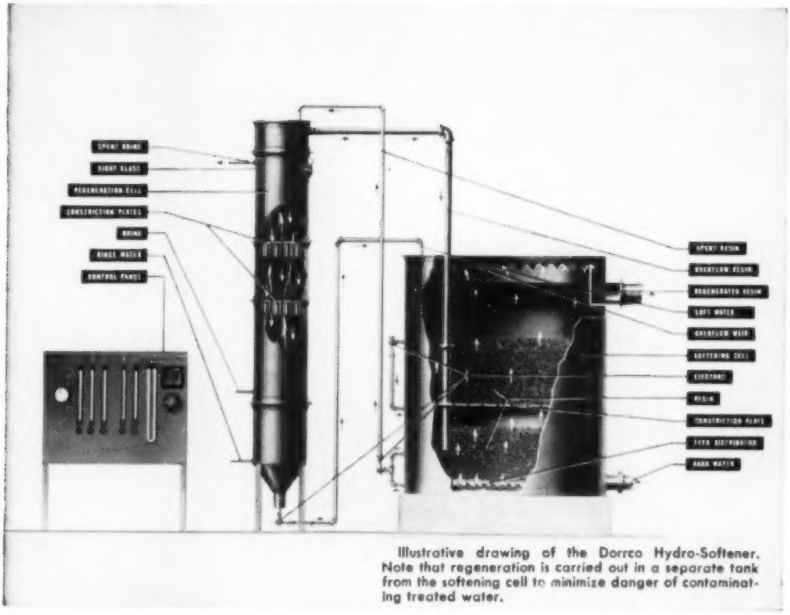
The Symbol for Service, Quality and Performance in Water Meters



Illustrative drawing of the Dorrco Hydro-Softener. Note that regeneration is carried out in a separate tank from the softening cell to minimize danger of contaminating treated water.

New! Base Exchange Softening Goes Continuous...

They said it couldn't be done. But at Baxter Springs, Kansas, a Dorrco Hydro-Softener has been in successful operation since October 1952. Both the softening cycle and the regeneration cycle are 100% continuous . . . no shutting down to regenerate and rinse, no periodic slug discharge of high salt content brine to contaminate the sewer . . . but a continuous supply of soft water at a constant quality going into the mains. What's more, installed cost of the Hydro-Softener is lower than with a conventional cation exchange softener and more efficient regeneration and lower rinse water requirements add up to lower operation costs.

If you'd like more information on this new development in water treatment practice, drop a line to The Dorr Company, Stamford, Conn. Bulletin No. 4083, just off the press, describes the Dorrco Hydro-Softener in detail. A copy is yours for the asking.

THE DORR COMPANY • ENGINEERS • STAMFORD, CONN.
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LEADITE

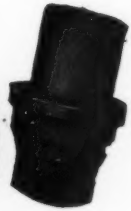
Jointed for . . . Permanence with LEADITE

Generally speaking, most Water Mains are buried beneath the Earth's surface, to be forgotten,—they are to a large extent, laid for permanency. Not only must the pipe itself be dependable and long lived,—but the joints also must be tight, flexible, and long lived,—else leaky joints are apt to cause the great expense of digging up well-paved streets, beautiful parks and estates, etc.

Thus the "jointing material" used for bell and spigot Water Mains MUST BE GOOD,—MUST BE DEPENDABLE,—and that is just why so many Engineers, Water Works Men and Contractors aim to PLAY ABSOLUTELY SAFE, by specifying and using LEADITE.

Time has proven that LEADITE not only makes a tight durable joint,—but that it improves with age.

The pioneer self-caulking material for c. i. pipe.
Tested and used for over 40 years.
Saves at least 75%

THE LEADITE COMPANY
Girard Trust Co. Bldg. Philadelphia, Pa.

No Caulking